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Decomposition of Residential and Light Commercial Solid Waste in Test Lysimeters

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DECOMPOSITION
OF RESIDENTIAL AND LIGHT COMMERCIAL SOLID WASTE IN TEST LYSIMETERS

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U.S. ENVIRONMENTAL PROTECTION AGENCY
1980

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ABSTRACT

The monitoring of eight large test lysimeter cells has given information about the decomposition of, and leachate and gas production from, shredded and unprocessed refuse. Six of the cells were originally 4 to 5 feet deep and held 100 tons each of residential-light commercial municipal solid waste. Two cells were originally 8 to 10 feet deep and held 200 tons each. All cells were exposed to the climate at Madison, Wisconsin, for 5 to 7 years.

Cell monitoring was designed to indicate changes in leachate quantity and composition and gas composition, as a result of: (1) shredding or not shredding the waste, (2) covering or not covering the waste with soil, (3) increasing the depth of a lift from 4 feet to 8 feet, and (4) building an 8-foot layer in a landfill in one or two lifts.

The volumetric rate of leachate production of all of the cells was found to vary seasonally and according to weather events. There appeared to be a direct correlation between leachate quantity and quality.

Increased peak concentrations of contaminants in leachate were common with shredded refuse, in comparison with unprocessed refuse. The effect of soil cover on the cells was to prolong the period of production of leachate high in contaminant concentrations. The cells left uncovered produced initially a highly contaminated leachate, followed by rapid stabilization to consistently low concentrations of contaminants.

Adding a new lift of refuse to cells which were already five years old indicated that partially decomposed solid waste has an ability to treat leachate as it passes through. The 8-foot deep cells constructed in one lift produced higher leachate concentrations and took substantially more time to stabilize than the comparable 4-foot cells.

This report was submitted in fulfillment of Contract 68-03-0315 by R.K. Ham of the University of Wisconsin at Madison under the partial sponsorship of the U.S. Environmental Protection Agency. This report covers the period June, 1970 to August, 1977, and work was completed as of August, 1978.

CONTENTS

Abstract iii
Figures v
Tables vi
Appendix Tables vi
Acknowledgement vii

1. Introduction 1
2. Conclusions 3
3. Recommendations 6
4. Lysimeter Design, Construction, and Monitoring Procedures 7
5. Results and Discussion of Results 13

Water balance 13

Precipitation 14
Runoff 14
Leachate 19
Overall water balance 20
Summary on water balance 22

Leachate quality 22

Interrelationships between curves and initial discussion of cells 1-4 23
COD concentration 30
Specific conductance 33
pH 33
Other leachate quality parameters 36
Summary on leachate quality 36

Production of contaminants in leachate 40
Gas composition 44

Oxygen 44
CO_2 48
CH_4 49
Summary on gas composition 51

Refuse temperature 51
Refuse moisture content 55
Settlement 55
Physical appearance of refuse after decomposition 57

References 57

Appendix 59

FIGURES

Number		Page
1	Plan view of test cell facility	8
2	Cross section of test cell	9
3	Test cell being filled with unprocessed solid waste	11
4	Cumulative precipitation	15
5	Runoff volume	16
6	Leachate volume	17
7	Cell 1 leachate volume - COD concentration - pH	24
8	Cell 2 leachate volume - COD concentration - pH	25
9	Cell 3 leachate volume - COD concentration - pH	26
10	Cell 4 leachate volume - COD concentration - pH	27
11	Leachate COD concentration	31
12	Leachate specific conductance	34
13	Leachate pH	35
14	COD production	41
15	O_2 concentration	45
16	CO_2 concentration	46
17	CH_4 concentration	47
18	Average refuse temperature	52
19	Refuse near the surface of cell 4 five years after cell construction	58

TABLES

Number		Page
1	Water Budget	18
2	Average Concentrations for Specific Leachate Tests	37
3	Production of COD - Summary of Data	42
4	Cumulative Settlement	56

APPENDIX TABLES

Number		Page
A-1	Precipitation Data and Chronology of Cell Construction	60
A-2	Runoff Volume	62
A-3	Leachate Volume	64
A-4	Leachate COD Concentration	66
A-5	Leachate Specific Conductance	68
A-6	Leachate pH	70
A-7	Leachate Calcium Hardness Concentration	72
A-8	Leachate Total Hardness Concentration	74
A-9	Leachate Alkalinity	76
A-10	Leachate Chloride Concentration	78
A-11	Leachate Total Iron Concentration	80
A-12	Leachate Ammonia -NConcentration	82
A-13	Leachate Organic -N Concentration	84
A-14	Leachate Ammonium -N Concentration	86
A-15	Leachate Nitrate -N Plus Nitrite -N Concentration	88
A-16	Leachate Total Phosphate Concentration	90
A-17	Leachate Soluble Phosphate Concentration	92
A-18	Average Leachate COD Production	94
A-19	Oxygen Concentration	96
A-20	Carbon Dioxide Concentration	98
A-21	Methane Concentration	100
A-22	Average Refuse Temperature	102

ACKNOWLEDGMENT

This project was initiated under EPA demonstration project grant 3-G06-EC-00000-0051, as part of the demonstration and evaluation of shredding municipally-generated solid wastes and landfilling the resulting material without daily cover soil. This project ended in 1973, whereupon, by prior agreement, lysimeter evaluations were continued under a separate EPA contract, number 68-03-0315. Numerous EPA personnel have been project officers, or have been otherwise close to the project over its existence. Of these, David Arella, Roger Graham, Truett DeGeare, and Toby Goodrich should be acknowledged for their input at critical phases of the project.

Many students have been involved with construction and maintenance of the test cells, collecting field data, performing chemical analyses, keeping records, interpreting data. Charles R. Anderson, Robert Karnauskas, and Todd Bookter are three students who are specially recognized for the importance of their association with the project.

The excellent cooperation of the City of Madison, and Gary Boley, in particular, in providing the expertise, men, and equipment necessary to do cell construction and major maintenance work is acknowledged. The Oscar Mayer Company provided the land, original sludge drying beds, and storage space for field equipment.

Finally, the Engineering Experiment Station of the University of Wisconsin and the City of Madison are acknowledged for their support of the later stages of the project. Without this support, data regarding the second lifts of cells 3 and 4, and confirmation of trends with the deep cells would not have been obtained.

SECTION 1

INTRODUCTION

This study began as one part of the large project carried out at Madison, Wisconsin, to demonstrate and evaluate the shredding of residential-light commercial solid wastes and the landfilling of the resulting material without daily cover. This original project was the joint effort of the City of Madison, The University of Wisconsin, The Heil Company of Milwaukee, and the U.S. E.P.A. (originally through the P.H.S.). Of major concern in the landfilling of shredded solid wastes without daily cover soil was the impact such practice would have on decomposition patterns of the landfill, and in particular leachate composition and amount, and gas production. Consequently, three decomposition studies were carried out as part of the demonstration program.

The first study utilized large piles of refuse placed over periods ranging from several weeks to months, which had plastic sheets under portions of each test landfill to collect leachate. Both shredded waste without soil cover and unprocessed waste with soil cover (sanitary landfill) test piles were built. The result was rather accurate evidence of the decomposition patterns of each type of landfill, but because of the lack of control in these large-scale tests, water balances, gas production, and leachate contaminant production information could not be obtained, and the effects of shredding the waste and soil cover could not be separated.

The second study used 600 pound samples of shredded and unprocessed solid wastes and subjected them to accelerated decomposition in separate rooms, each with a controlled environment. The result was interesting with respect to water movement and patterns of leachate composition, but decomposition patterns were incomplete as methane production was minor.

The third study was designed to provide information about decomposition changes occurring both as a result of shredding and using soil cover, separately. Test cells or lysimeters were carefully designed and operated to provide such information.

The first two studies were completed and reported in reference (1). The third study was of particular importance because of the design and degree of control used to assure proper comparison of test results, and so it was extended to provide more test cells as a check on the effects of shredding and cover and also to give information on the effect of depth of waste on decomposition. The third study was incomplete at the conclusion of the original shredding demonstration program. It was continued through a direct contract from EPA to The University of Wisconsin. This report is the final report covering both the design, construction, and initial monitoring of the test cells, as reported in detail in reference (1), as well as subsequent monitoring as performed under the contract.

The eight test cells or lysimeters were large enough to allow full-scale landfill equipment to be used, to minimize edge effects, and to be able to consider the waste in each cell as being representative (i.e., particle sizes were much less than lysimeter sizes). The first four test cells were constructed in September of 1970 and consisted of unprocessed refuse with soil cover, and shredded refuse with cover, without cover, and covered six months after refuse placement, respectively. The four remaining cells were constructed in August of 1972 and consisted of unprocessed refuse both without cover and with shredded refuse as the only cover, plus two cells twice as deep as the other six cells, containing shredded refuse without cover and unprocessed refuse with soil cover, respectively. Finally, in July, 1975, two of the first set of four cells received second lifts of solid waste, bringing their total fresh refuse height to that of the two deep cells, to allow determination of whether leachate generated by overlying lifts of solid wastes was treated or attenuated by underlying layers of relatively decomposed or stabilized waste.

It should be noted that the last one and one-half years of data, which were critical in documenting the later stages of the effect of depth, and the attenuation of leachate from upper lifts, were made possible by the Engineering Experiment Station of The University of Wisconsin, The City of Madison, and numerous others who helped in a variety of ways to continue the monitoring effort beyond that made possible by the E.P.A.

SECTION 2

CONCLUSIONS

The following conclusions have been reached, subject to the conditions and limitations of this study.

(1) The water budget was affected by the presence or lack of soil cover, with the presence of cover increasing the runoff from an average of 3.3% for all cells without cover to 8.8% for all covered cells over the entire period of monitoring. The presence of cover decreased evapotranspiration from an average of 82.0% for all cells without cover to 72.3% for the covered cells. The effect on leachate production was mixed.

(2) Shredding of the solid waste had little or no effect on the water budgets of the covered cells, but shredding resulted in less evapotranspiration and more leachate production for the cells with no soil cover.

(3) The amount of runoff from all cells without soil cover was small, averaging 3.3% of precipitation, but did increase with time as the cell surfaces became vegetated and decomposed to a more soil-like consistency.

(4) In comparing the water budgets of unprocessed solid waste covered with soil and shredded waste without cover (i.e., sanitary landfill and "millfill", respectively), the shredded waste without cover produced approximately the same percentage of rainfall as leachate as the covered unprocessed cells, as a result of the decreased amounts of runoff being compensated by increased evapotranspiration.

(5) Soil cover either directly or indirectly served to keep the solid waste cooler as indicated by waste and leachate temperatures.

(6) Soil cover greatly affected the decomposition of both shredded and unprocessed solid wastes. With both kinds of waste, the immediate application of soil cover resulted in steady, but highly contaminated, leachate production over much of the 5- to 7-year period; whereas, the absence of cover resulted in rapid decomposition to produce a very highly contaminated leachate for a relatively short period, followed by a sharp dropoff to leachate of relatively low contaminant concentrations. The time required to "stabilization" of the shallow (4 foot) cells, as indicated by consistently low COD concentrations, was roughly 3 years for the covered cells and one year for the cells without soil cover, irrespective of whether the solid waste was shredded. The deep cells (8 feet) showed the same effect of cover, but over longer time periods, with the cell without cover slowly stabilizing over the entire five years of monitoring, but not yet reaching stable, low COD concentrations, and the cell with cover not yet showing signs of stabilization at the conclusion of the five-year monitoring period.

(7) Shredded solid waste decomposed more quickly than did unprocessed waste as indicated by higher initial temperatures, a more contaminated leachate during comparable stages of decomposition, and the more rapid onset of methane production. This was probably a result of increased particle surface area, homogenization of the waste, and more uniform movement of moisture.

(8) A clear relation existed between climatic events and leachate production and quality. Freezing conditions or dry spells led to low levels of leachate production and to decreased contamination levels of whatever leachate was produced. Conversely, spring thaws or large amounts of rainfall gave rise to increased leachate quantities and higher contaminant concentrations. Prolonged wet or dry periods led to prolonged changes in leachate production and quality; short term climatic events led to short term changes. Rapid leachate movement apparently rinsed matter out of the cells and/or upset whatever degree of decomposition process stability had been achieved, resulting in increased leachate contaminant concentrations.

(9) Covering shredded solid waste with soil after six months temporarily increased contaminant concentrations in the leachate by physically squeezing matter out of the waste during the application of cover. Being without cover for six months was, however, sufficient to cause this cell to assume the general decomposition patterns of uncovered solid waste, in that it reached stable conditions quickly, producing relatively dilute leachate consistently, comparable to the cells which were never covered. This data indicates that it was advantageous, as far as limiting contamination by leachate is concerned, to allow shredded refuse to decompose for six months before covering it with soil.

(10) The effect of doubling the depth of solid waste was to extend by a considerable amount the time span required for similar discernable decomposition patterns to occur. For the shredded cells without cover, the time required to reach consistantly low COD concentrations was approximately one year for the shallow cells and at least five years for the deep cell. For the unprocessed refuse cells covered immediately, approximately 5 years was necessary for the shallow cell to become stable, whereas the deep cell indicated no sign of stabilization after five years. Doubling the solid waste depth more than doubled concentrations during comparable periods of decomposition of the major leachate contaminants.

(11) The lower lifts of partially stabilized solid waste in cells 3 and 4 were able to significantly reduce leachate contaminant production from upper lifts by treating or attenuating leachate from the upper lifts. The upper lifts were added to these cells five years after placement of the lower lifts. For shredded solid waste without soil cover, the lower lift apparently decreased the leachate COD produced over one and one-half years by the upper lift from 311 kg COD to 109 kg COD, for a reduction of 65%. With shredded waste covered immediately, cell 2 produced 353 kg COD over the first one and one-half years. The amount of COD released from cell 3 for one and one-half years after the second lift was added was 7.1 kg, for a reduction in COD of 98%. The first lift of cell 3 could not

be used as a basis for comparison because it was left without cover for six months. Both lower lifts were producing minor amounts of COD at the time the second lifts were added.

(12) The two cells with unprocessed refuse but without cover soil (one without any cover at all and the other with shredded refuse as cover) had the lowest leachate contaminant concentrations and methane gas concentrations of all the test cells, which might be considered favorable in some landfill situations. However, serious aesthetic and possibly health problems were associated with these cells. In both cases they experienced odor, fly, and rodent problems. The uncovered cell was visually unacceptable. This study indicated that the use of shredded refuse as cover over unprocessed refuse is dangerous, but such practice may eventually prove to be acceptable by using a thick layer of shredded refuse as cover which is carefully controlled and monitored.

SECTION 3

RECOMMENDATIONS

There are many aspects of this research which suggest further study, but the most obvious suggestions are as follows:

(1) The effect of depth of a landfill on decomposition processes in general and leachate quality in particular needs complete, long-term study. Only two depths were examined here, both selected to be shallow compared to full-scale landfilling practice in order to obtain results in a reasonable time. Additional depths need to be examined over periods sufficient to reach steady, low-level degrees of leachate contamination.

(2) There is probably an optimum time interval between placement of successive lifts which would minimize leachate contamination both for shredded and unprocessed solid waste. This should be investigated so that landfill lifts can be sequenced in order to minimize adverse leachate effects.

(3) The concept of lack of cover soil changing decomposition patterns of a lift, so as to reduce greatly the period over which highly contaminated leachate is produced, can be of great practical significance. Additional work needs to be done to determine whether an optimum waiting period until application of cover exists, and whether cover soil and additional lifts of solid waste act similarly in this regard.

SECTION 4

LYSIMETER DESIGN, CONSTRUCTION, AND MONITORING PROCEDURES

The recent and popular method of processing refuse by shredding or milling is said to promote high quality landfill operations and make the landfill more acceptable to the public. Shredded refuse is reported to not require daily soil cover. This study was undertaken to examine changes in the decomposition processes and the products of decomposition resulting from use of various options of landfill design or operation. The original objective was to compare shredded and unprocessed refuse both with and without soil cover with respect to products of decomposition. The study was expanded later to look also at the long-term effects of landfill depth, the use of shredded refuse to cover unprocessed refuse, and the attenuation of leachate by previously deposited and relatively decomposed lifts of shredded refuse.

Eight test cells were constructed to evaluate different landfill conditions, as shown in plan view in Figure 1. The size of the cells was selected to be large enough to provide reasonably uniform refuse composition, large enough to be worked by regular landfill machinery following normal procedures, and large enough to develop representative water flow patterns within the refuse. Each cell was 30 × 60 ft (10 × 20 m) in surface area. Six cells were nominally 4 ft (1.3 m) deep and had 100 tons (91 metric tons) of refuse each. Two additional cells were nominally 10 ft (3.3. m) deep and had 215 tons (196 metric tons) of refuse each. Because of the sloping of the tops and bottoms of all cells, an exact depth is difficult to define. The actual solid waste depth varied initially from 3 to 5 feet in the 4-foot cells, and from approximately 7 to 10 feet in the deep cells. Settlement and periodic reworking of cell surfaces to maintain runoff characteristics further complicates a strict definition of cell depths. Accordingly, the cells will be referred to as 4 or 8 foot deep, or shallow or deep, for the remainder of this report.

Cement walled, abandoned sludge drying beds, each 60 by 60 feet, were used. A cross section view of two adjacent cells, using one drying bed, is shown in Figure 2. All cells were constructed below grade and had three walls made of cement and a fourth of wood which divided each drying bed into two test cells. The cement walls in the 4-foot cells were vertical; whereas, the 8-foot cells had 5-foot vertical cement walls over a 45° sloped bottom, constructed by contouring the cell bottoms to give the additional depth. The bottoms of all cells were graded at approximately 3% to carry leachate to a central collection reservoir. The bottom of each cell consisted of graded, compacted sand, covered with 4 inches of crushed stone and a 1 in. (2.5 cm) bituminous layer. Over the bituminous layer a 6 mil polyethylene sheet was placed, followed by a 4-inch (10 cm) thick layer of crushed, coarse granite to act as a leachate carrying layer. The granite was tested specifically to be sure it would not affect leachate quality. Cell surfaces were sloped at approximately 3% to one side where runoff was collected by a rain gutter arrangement for runoff volume measurement. Because both the top surface grade and the bottom surfaces of all cells were graded away from the

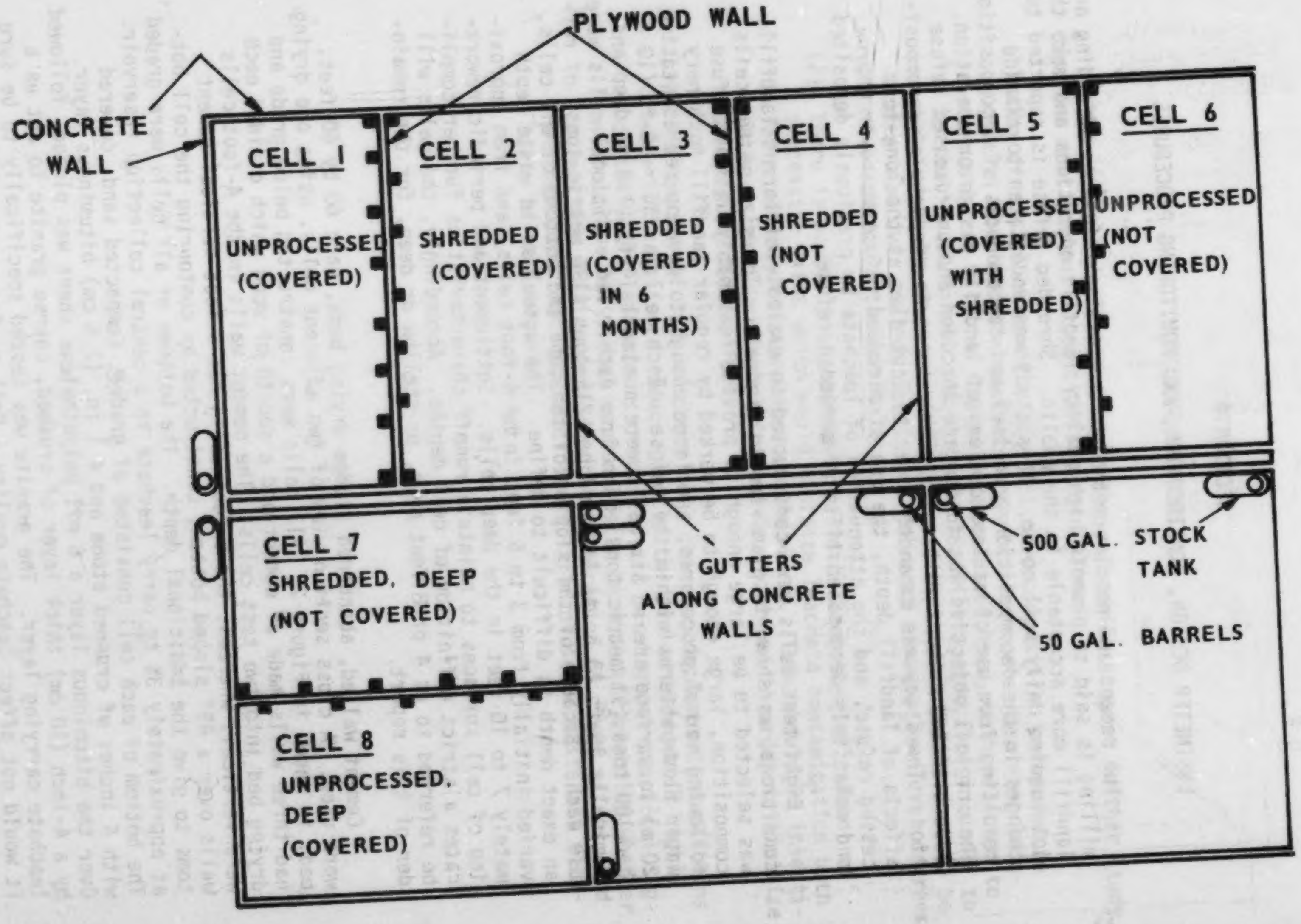
PLYWOOD WALL
CONCRETE WALL
CELL 1
UNPROCESSED (COVERED)
CELL 2
SHREDDED (COVERED)
CELL 3
SHREDDED (COVERED) IN 6 MONTHS)
CELL 4
SHREDDED (NOT COVERED)
CELL 5
UNPROCESSED (COVERED) WITH SHREDDED)
CELL 6
UNPROCESSED (NOT COVERED)
CELL 7
SHREDDED, DEEP (NOT COVERED)
CELL 8
UNPROCESSED, DEEP (COVERED)
GUTTERS ALONG CONCRETE WALLS
500 GAL. STOCK TANK
50 GAL. BARRELS

FIGURE 1. PLAN VIEW OF TEST CELL FACILITY.

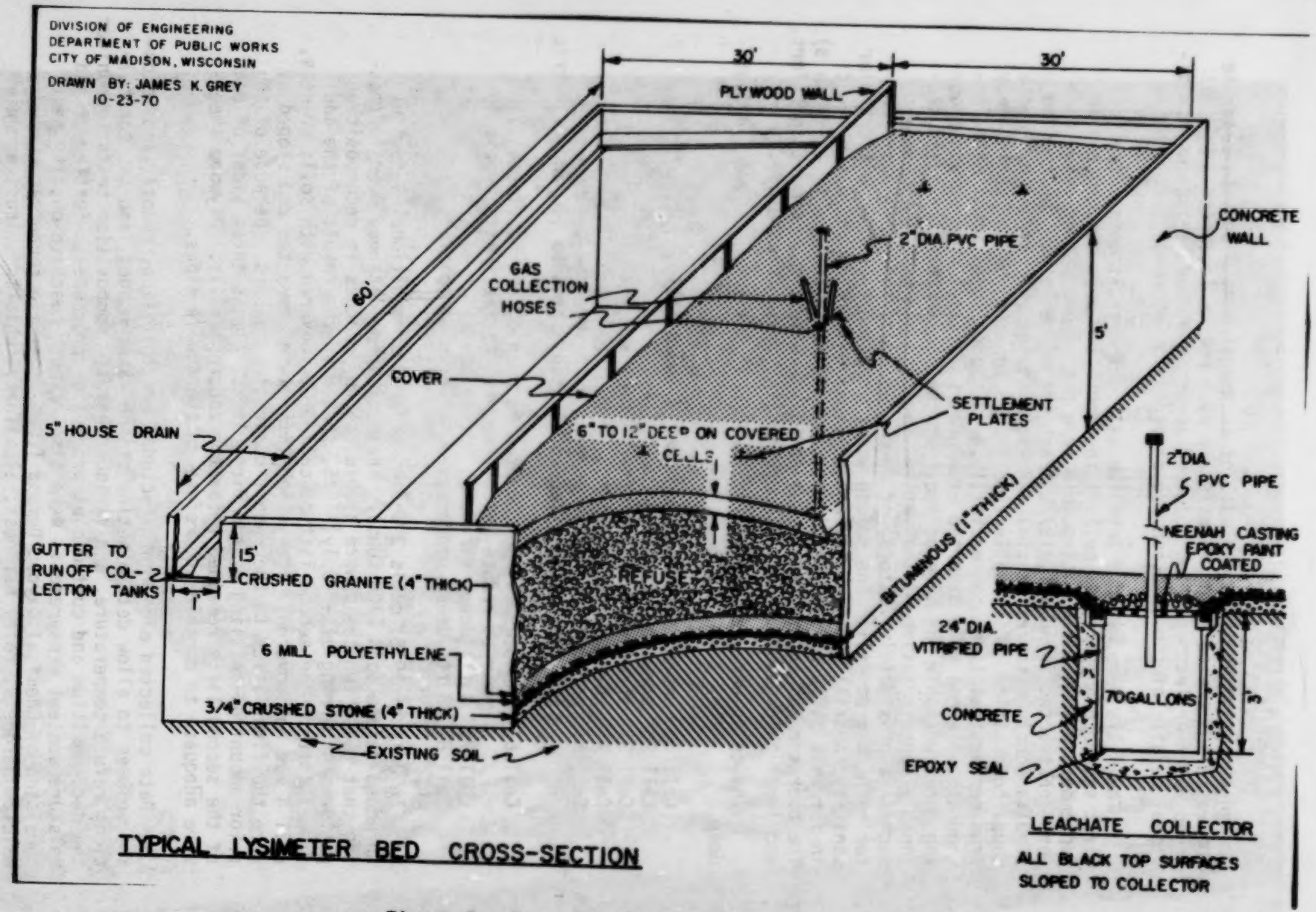
DIVISION OF ENGINEERING
DEPARTMENT OF PUBLIC WORKS
CITY OF MADISON, WISCONSIN
DRAWN BY: JAMES K. GREY
10-23-70
30'
30'
PLYWOOD WALL
60'
GAS COLLECTION HOSES
2" DIA. PVC PIPE
CONCRETE WALL
5'
COVER
SETTLEMENT PLATES
5" HOUSE DRAIN
6" TO 12" DEEP ON COVERED CELLS
2" DIA.
PVC PIPE
NEENAH CASTING
EPOXY PAINT COATED
BITUMINOUS (1" THICK)
GUTTER TO RUNOFF COLLECTION TANKS
1.5'
1'
CRUSHED GRANITE (4" THICK)
REFUSE
24" DIA. VITRIFIED PIPE
6 MILL POLYETHYLENE
70 GALLONS
CONCRETE
3/4" CRUSHED STONE (4" THICK)
EPOXY SEAL
EXISTING SOIL
TYPICAL LYSIMETER BED CROSS-SECTION
LEACHATE COLLECTOR
ALL BLACK TOP SURFACES SLOPED TO COLLECTOR

Figure 2. Cross section of test cell.

wooden partition, this fourth wall of each cell served only to separate the waste in each cell and to maintain each cell's integrity. Minimal or no water or leachate flow occurred across the wood partitions. Additional details of construction are provided in reference (1).

The cells were divided into two sets. The cells comprising the first set were numbered as cells 1 through 4 and were constructed in September, 1970. Cells 5 through 8 were the second set of cells and were constructed in August, 1972. Each set of cells was constructed simultaneously with residential and light commercial refuse to promote equal composition. City collection trucks known to be collecting only from residential-light commercial (i.e., an occasional small neighborhood store) areas were diverted at random to the cells or shredder during construction. The time of year was chosen specifically to be reasonably representative of the entire year's refuse composition. Six inches (approximately 75 tons) of compacted sandy-silt soil was used for each covered cell. The refuse was placed and compacted with regular sanitary landfill machinery by an experienced operator who was brought in for this purpose from the city's sanitary landfill site (see Figure 3). The operator was instructed to use normal machine time, compaction effort, and layer thickness, as far as he could, in working the refuse.

The cells were numbered as follows. Cells 1 through 6 were 4 feet deep.

Cell 1: unprocessed refuse, covered immediately,
Cell 2: shredded, covered immediately,
Cell 3: shredded, covered after 6 months,
Cell 4: shredded, not covered,
Cell 5: unprocessed refuse covered with shredded refuse (66 tons unprocessed and 30 tons shredded (60 and 27 metric tons)),
Cell 6: unprocessed, not covered (screened for the first year to reduce insect, rodent, and aesthetic problems),
Cell 7: 8 ft. deep, shredded, not covered,
Cell 8: 8 ft. deep, unprocessed, covered immediately.

In July of 1975, cells 3 and 4 received an additional 4 feet of shredded refuse each (100 tons). The monitoring data had been indicating that these two cells were stable, so any changes in decomposition patterns occurring after July, 1975, should be the result of the additional lifts. The second lift of cell 3 was covered with soil; whereas, cell 4 was not covered. The second lifts were compacted and sloped as were the first lifts to the runoff collection gutters. Because of the prior amount of settling of the first lifts, almost three sides of each of the second lifts remained below the concrete walls. Plywood sheets were adequate to contain the refuse on the fourth sides.

Data collected each month included precipitation, runoff, and leachate volumes to allow determination of the water budget, and gas composition, refuse temperature, and various leachate composition tests to monitor the decomposition and contaminant production processes. Settlement and moisture content measurements were also taken. Leachate quality tests consisted of Chemical Oxygen Demand (COD), specific conductance, pH, calcium hardness, total hardness, alkalinity, chloride, iron, ammonia nitrogen, organic nitrogen, total ammonium nitrogen, nitrate plus nitrate nitrogen, and total and soluble phosphate.

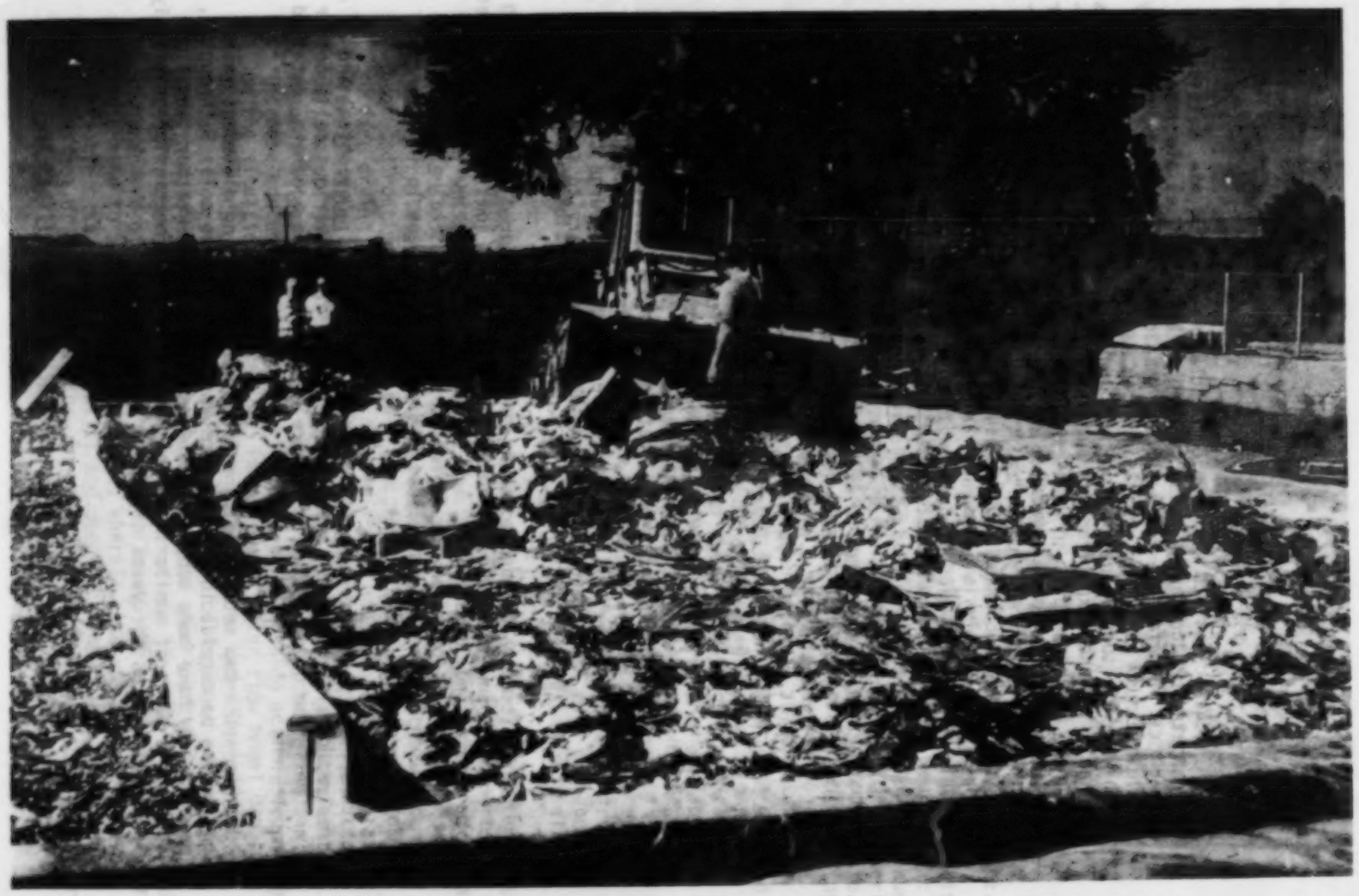

Figure 3. Test cell being filled with unprocessed solid waste.

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All chemical tests were run on settled samples (30 min. settling) of leachate in accordance with "Standard Methods" (2), as discussed in more detail in reference (1). Settled samples were found to be necessary to avoid random variations resulting from sample particulate contents which were, in turn, dependent on hose location during sampling. Samples for analysis were taken from approximately the mid-point as leachate collected in the reservoirs in each cell was pumped out at least monthly for quantity determination. Liquid volumes were determined by pumping leachate or runoff into large calibrated tanks, and precipitation data was obtained from a U.S. Weather Bureau Station located in the immediate vicinity. Gas analysis was done with a Fisher Gas Partitioner, Model 25V. Gases were sampled by suction through the bottom portion of galvanized steel pails, perforated to allow gas flow, and inverted and placed in the refuse. This system collapsed or plugged occasionally, especially in the deep cells as upper layers of refuse settled. Replacement probes were constructed of 1-inch steel pipe, threaded to a conically-shaped steel driving point which was drilled out to allow gas collection radially. Gases were sucked through the holes in the driving point, through copper tubing attached directly to the point and running the length of the pipe and into the suction collection vessel system. Gases were collected in 250 ml glass gas sampling flasks connected via rubber tubing to the pail or point in the landfill. Suction was provided by an electric vacuum pump, protected by a trap flask, and operated with a portable generator. Initial testing and periodic verification determined that 45 seconds at a vacuum of 5 psi was adequate to purge the system, as discussed in reference (1). This testing involved the filling of multiple flasks after purge times ranging from 0 to 120 seconds and noting the time necessary to safely purge air from the system.

Refuse temperature and moisture content was measured with Model MC360 Standard Moisture Cells, and read with a model MC300A soil moisture ohmeter, both manufactured by Soiltest, Inc., of Baraboo, Wisconsin. Moisture determination is based on the resistance between two metal plates in the probe. Temperatures were obtained by use of a thermocouple incorporated in each probe.

The most pertinent data is presented in two forms: graphical and tabular. One can identify trends and patterns of the various cells better by viewing the graphs. The tables are given to provide accurate, detailed results.

Since the two sets of cells were constructed during different years, one has to be careful in comparing cells 1 through 4 to cells 5 through 8, because they have been subjected to somewhat different weather conditions during the years of monitoring. This potential error becomes progressively less important as the years of monitoring increase.

SECTION 5

RESULTS AND DISCUSSION OF RESULTS

WATER BALANCE

Special care was taken in construction to insure that no water could leak through the bottom or sides of each cell. Thus, all precipitation had to run off the sloped surface of each cell, infiltrate into the surface of the cell and percolate downward, or evapotranspirate. Water which infiltrates into a cell will raise the moisture content gradually of each layer of solid waste until the waste is at field capacity, at which point additional infiltration will result in water leaving that layer and flowing downward to the next layer, etc. This process continues until the entire cell is at field capacity and produces leachate regularly. Water leaving a volume of solid waste in this fashion is called leachate. Theoretically, no leachate would be collected from a solid waste mass (or lysimeter cell) until all of the waste is at field capacity.

There are complications in this simplified concept of water flow in solid waste, such as non-uniform wetting characteristics of different wastes, the rapid flow of water through voids in the solid waste (channeling), and the effect of capillary action. This is true especially during the early stages after waste placement before field capacity and stable conditions are achieved. However, the long-term flow can be described simply by the following equation:

Precipitation = runoff + evapotranspiration + leachate.

Complications due to non-uniform solid waste wetting characteristics and channeling give rise to non-uniform movement of the moisture front downward through the solid waste, resulting in steadily increasing amounts of leachate collected at the bottom as more and more of the solid waste reaches field capacity. Once field capacity is achieved, leachate is produced routinely and will be a function of incident precipitation and surface drying conditions, varying in amount according to precipitation after some lag period. Channeling would be expected to reduce water-solid waste contact, thereby resulting in lower leaching contaminant concentrations through lack of contact. Conversely, channeling can increase concentrations temporarily through a flushing action, depending on the situation. Complications in the simple water flow model due to capillary action arise when capillary forces move water against the forces of gravity. In the case of these test cells, such action would tend to hold more moisture than normal in the upper portions of the landfill, thereby increasing evapotranspiration. The use of the crushed stone underdrain to facilitate leachate flow to the collection reservoir would tend to accentuate this effect; whereas, the use of moderately-permeable cover soil (sandy-silt) and deeper cells would tend to reduce the effect of capillary action, in not releasing moisture to lower layers of less capillary pull (moisture tension), on the water balance.

Precipitation

Cumulative precipitation from the beginning of the experiment through June, 1977, is given in Figure 4 (also Table A-1). Two scales are presented in Figure 4. The outer scale is for cells 1 through 4 which were constructed in mid-September, 1970. The inner scale is for cells 5 through 8 which were constructed in mid-August, 1972. Of importance is increased precipitation amounts for the latter part of September, 1970, when cells 1 through 4 were being constructed and, also, for the latter part of August, 1972, when cells 5 through 8 were being constructed. Note that the spring months of March to May typically have a high amount of rainfall. Of significance, also, is the unusually large amount of precipitation in the spring of 1973, and the spring and summer of 1975. Rainfall, in the spring of 1973 was especially heavy and had a major impact on the data, as will be observed later. Note, also, the lack of precipitation in 1976.

Runoff

Theoretically, the flow of water should be controlled by the surface characteristics of each cell. The cells which were covered should have similar water flows and the cells which were not covered would be expected to act alike, but quite differently from the covered cells. The runoff and leachate volume data, Figures 5 and 6 (Table A-2) and (Table A-3), respectively, show such a result. (Note that a tabular presentation of the data, expressed as percentages of precipitation resulting in leachate, runoff, and evapotranspiration (by difference) will be presented in Table 1 for each cell for each year. This table will be discussed after the general discussion of Figures 5 and 6.)

Figure 5 and Table A-2 indicate that the rate of runoff was affected primarily by whether cover was or was not applied to the cells. The major fluctuations in the amount of runoff for individual cells were due to freezing conditions in the winter, thawing conditions in spring, and periods of more or less precipitation. The intensity and duration of precipitation were factors influencing the routing of precipitation to runoff and, in turn, the amount infiltrated into the cells. Runoff was observed immediately from the covered cells and continued at about the same rate over most of the testing period. The cells without cover exhibited a lag period after construction before runoff was produced, during which cell surfaces were being wetted. They also displayed a low but slowly increasing rate of runoff over the first several years. The covered cells did not exhibit any such trend with time. After a period of about four years, the covered and uncovered cells had similar runoff rates. This was probably due to the surface characteristics of the shredded uncovered cells which changed from that of absorptive shredded paper initially to a soil-like material as decomposition took place. The occurrence of volunteer vegetation on the cells caused both the covered and uncovered cells to have low runoff rates and, also, helped camouflage any differences in soil/refuse surface characteristics with time.

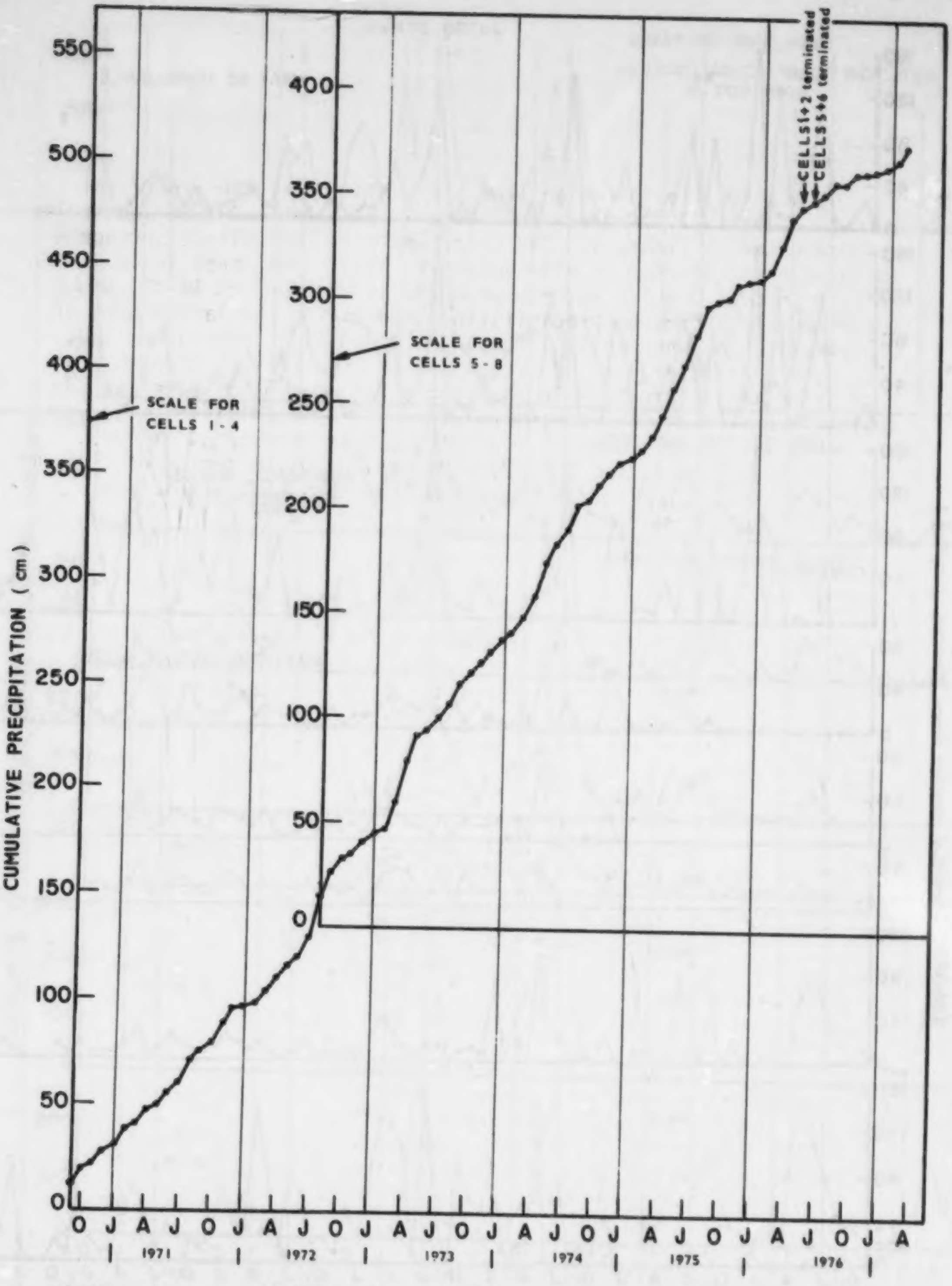

FIG. 4 CUMULATIVE PRECIPITATION (cm)

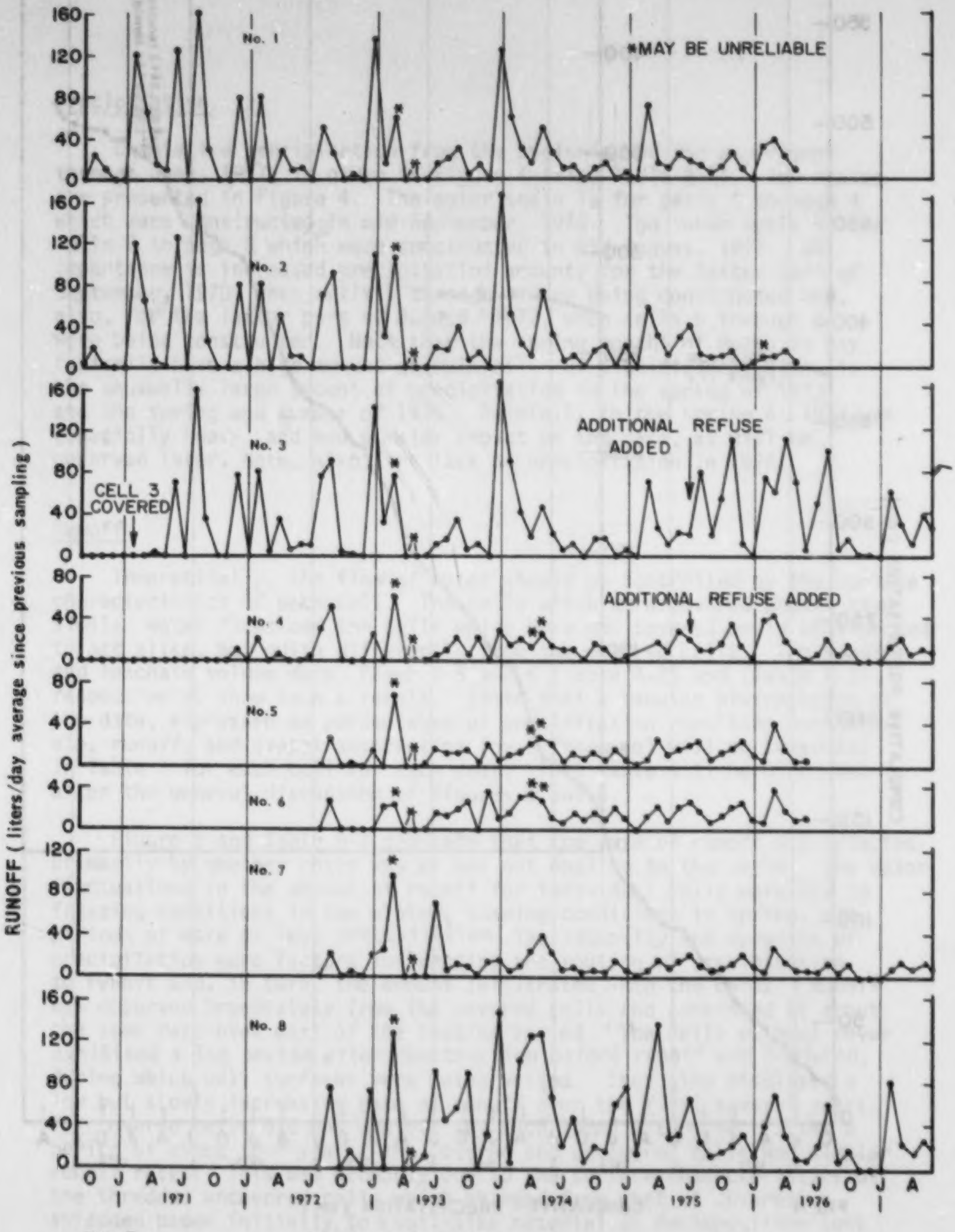

FIG. 5 RUNOFF VOLUME (liters/day)

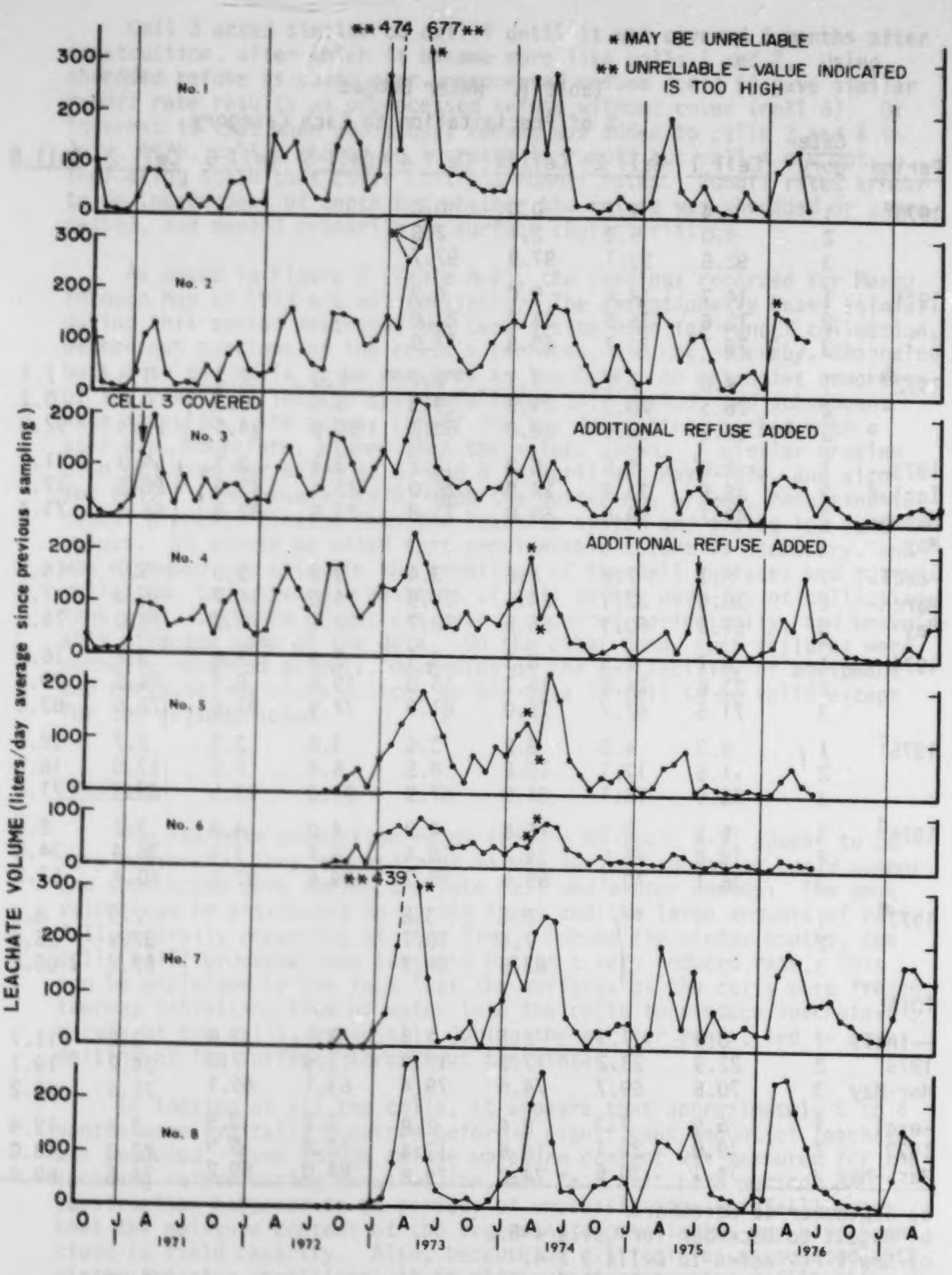

FIG.6 LEACHATE VOLUME (liters/day)

Table 1. Water Budget

Period	Category	% of Precipitation to Each Category Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
1970[a]	1	2.4	1.7	0.0	0.0				
	2	5.0	5.2	2.1	2.3				
	3	92.6	93.1	97.9	97.7				
1971	1	14.7	14.4	9.0	0.3				
	2	12.6	15.6	21.2	21.8				
	3	72.7	70.7	69.8	77.9				
1972[b]	1	4.6	7.2	7.1	2.7	2.0	2.2	1.8	7.1
	2	26.5	26.9	24.9	29.3	3.4	3.3	0.8	0.1
	3	68.9	65.9	68.0	68.0	94.6	94.5	97.4	92.8
1973—Includ. March-May	1	5.8	6.6	6.2	3.2	3.1	3.3	4.9	11.4
	2	46.5	33.9	24.8	25.0	23.4	13.9	28.5	17.2
	3	47.7	59.5	69.0	71.8	73.5	82.8	66.6	71.4
-excl. March-May	1	8.1	7.8	8.6	3.4	3.3	5.0	5.7	16.2
	2	30.6	32.1	24.6	25.9	24.6	16.7	16.3	7.9
	3	61.3	60.1	66.8	70.7	72.1	78.3	78.0	75.9
1974	1	6.7	7.5	8.3	3.1	2.9	3.8	3.2	16.3
	2	21.8	24.8	15.7	15.0	19.6	8.7	24.2	20.2
	3	71.5	67.7	76.0	81.9	77.5	87.5	72.6	63.5
1975[c]	1	4.3	4.8	8.2	3.6	3.6	3.9	2.7	12.5
	2	11.8	17.1	10.8	8.5	5.4	2.6	17.0	16.3
	3	83.9	78.1	81.0	87.9	91.0	93.5	80.3	71.2
1976[d]	1	5.1	2.3	15.8	4.9	4.0	4.3	3.2	8.5
	2	18.8	27.6	14.7	16.4	6.4	3.4	36.4	34.0
	3	76.1	70.1	69.5	78.7	89.6	92.3	60.4	57.5
1977[e]	1			8.8	3.2			2.9	8.0
	2			7.6	10.1			37.9	25.8
	3			83.6	86.7			59.2	66.2
TOTAL									
—incl. 1973 Mar-May	1	6.5	7.1	8.2	2.8	3.1	3.6	3.3	11.7
	2	22.9	23.2	17.2	17.8	13.8	7.3	24.2	19.1
	3	70.6	69.7	74.6	79.4	83.1	89.1	72.5	69.2
-excl. 1973 Mar.-May	1	6.9	7.3	8.6	2.8	3.2	3.9	3.2	12.4
	2	19.0	22.1	16.6	17.4	12.8	6.9	22.0	18.0
	3	74.1	70.6	74.8	79.8	84.0	89.2	74.8	69.6

a) September to December.
b) August to December for Cells 4-8.
c) New lifts added to Cells 3 & 4.
d) January to May for Cells 1-2;
January to June for Cells 5-6.
e) January to June.

1) Runoff.
2) Leachate.
3) Evapotranspiration (or, initially, water uptake).

Cell 3 acted similar to cell 4 until it was covered 6 months after construction, after which it became more like cells 1 and 2. Using shredded refuse as cover over unprocessed refuse (cell 5) gave similar runoff rate results as unprocessed refuse without cover (cell 6). Of interest is that when additional refuse was added to cells 3 and 4 in July, 1975, cell 3 showed an increase in runoff but cell 4 did not, indicating again that cover controls runoff rates. Runoff rates appear to be independent of depth and whether the refuse was shredded or unprocessed, and depend primarily on surface characteristics.

As noted in Figure 5 (Table A-2), the readings recorded for March through May of 1973 are not realistic. The exceptionally heavy rainfall during this period destroyed the tank system used for runoff collection, washed out portions of the cells's surfaces, and was, thereby, channeled back into the cells to be measured as leachate. An extensive reworking of the runoff collection system followed this period, and subsequent data is valid. The actual runoff for the data points marked with a star was, therefore, higher than the values shown. A similar problem also occurred for cells 4, 5, and 6 in April and May, 1974, and also for cell 2 in February, 1976, when the gutter was broken, resulting in runoff probably flowing into the leachate system and giving low runoff values. It should be noted that considerable effort is necessary, and was expended, to maintain the condition of the cell surfaces and gutter/collection tank system. Washouts of soil cover, cave-ins of collection tank pits, settling of gutters, etc., occurred periodically, and unavoidably affected some of the data. On the other hand, such failures were normally repaired quickly, depending on the availability of equipment and personnel on short notice, so the data is felt to be valid except for the periods noted.

Leachate

The leachate production rates (Figure 6, Table A-3) appear to be very seasonal. They reached peak values in late spring or early summer and approached zero during the late fall and winter months. The peak values can be attributed to spring thaws and the large amounts of rainfall generally occurring at this time. During the winter months, the cells still produced some leachate but at a very reduced rate. This can be explained by the fact that the surfaces of the cells were frozen, thereby inhibiting flow of water into the cells to produce leachate. Warmth of the cells, especially during the earlier years, led to some melting at the surfaces throughout the winter.

In looking at all the cells, it appears that approximately 5 to 6 months were typically required before a significant amount of leachate was produced. Even though refuse moisture content was measured for the incoming refuse during construction, the fact that both periods of construction happened to be periods of unusually high rainfaill means that the moisture content at the beginning of monitoring may have been close to field capacity. Also, because of difficulties associated with winter freezing conditions, it is difficult to determine infiltration and, therefore, water uptake by the cells in order to reach field capacity. For these reasons, no calculations will be made here attempting to compare the predicted onset of regular leachate production (using refuse tonnage, moisture content, field capacity, and precipitation data) with leachate volume data. Such calculations are presented for related portions of the initial demonstration project in reference (1).

The curves for the volume of leachate for cells 1 and 2 are very similar throughout the testing period. Cell 1 appears to have a slightly greater tendency to fluctuate in leachate volume than cell 2. Cell 4 had a greater leachate production than cell 2 for the first few years, after which the cells reversed, with cell 2 producing leachate at a greater rate. The leachate production rate for cell 3 tends to be somewhere in between that for cells 1 and 2 except for the extraordinary amount of leachate squeezed out of this cell by heavy machinery when cover was applied after six months. The first point of each curve for cells 1 to 4 is abnormally high because of rains while the cells were under construction.

The additional refuse added to cells 3 and 4 in July, 1975, resulted in somewhat decreased amounts of leachate produced as the new refuse took up moisture. The high value for cell 4 in July, 1975, was due to leachate being squeezed out of the cell by heavy machinery used to place the additional waste. This effect was not as noticeable in cell 3, probably because of the effect of the cover originally applied to the first 4 feet of refuse 6 months after its construction.

Cell 5 appears, after a couple of years, to be tapering off to low leachate production rates. This is due in part to lower amounts of precipitation during this period and to the increasing importance of surface vegetation. This cell compares well with cell 4 which also had a shredded refuse surface without cover soil.

Cell 6 (unprocessed refuse without soil cover) shows a constant low leachate production rate throughout the monitoring period. One might have expected more leachate from this cell than the others because of rapid channeling; however, apparently because of good compaction and the high potential for evaporation, this cell actually exhibited the lowest rate of leachate production of all the cells.

The two deep cells (cells 7 and 8) tended to produce leachate at greater rates and fluctuated more than the other cells. The reason for this is not known, but differences related to capillary action, density, smoothness of cell surfaces, and settlement to allow ponding on the surfaces could be responsible.

Points marked with one or two stars in Figure 6 deserve special mention. Because of problems discussed previously during periods of high rainfall (in the section on runoff), the values shown for leachate volume are probably too high. This is especially true for the points marked with two stars. Any runoff circumventing the runoff collection system or passing through breaks in washouts in the cell surfaces would be measured as leachate.

Overall Water Balance

Water balances are indicated for the cells in Table 1 in such a way that trends from year to year as well as overall summaries for the monitoring period can be observed. Because of errors introduced in the spring of 1973, the data is presented in a way both to include and exclude this period. Note that all the cells had high amounts of apparent evapotranspiration and low amounts of runoff and leachate for the first four to five months. This is due to the fact that the cells had yet to achieve field capacity and most of the moisture was being absorbed by the refuse and any soil cover. Since evapotranspiration was calculated by difference, moisture uptake is included in the evapotranspiration figures. Also, those cells without cover had reduced runoff and increased evaporation at first due to the relatively loose and undecomposed refuse at the surface during this period.

Table 1 indicates once again that the covered cells had a higher percent runoff in comparison with the uncovered cells. Cell 3, which was leveled, covered with soil, and compacted again six months after initial placement, exhibited the highest percent runoff of the 4 ft cells. By being leveled again after six months, the problem of ponding due to settlement of the cell's surface was reduced. The cells without soil cover show a higher percent evapotranspiration than the comparable covered cells (cells 4, 5, and 6 vs 1, 2, and 3; also cells 7 vs 8). As pointed out previously, the presence of refuse in general, but paper particles in particular, on the surfaces of the uncovered cells apparently promoted evaporation. Also, it was noted that vegetation (volunteer) appeared more quickly, and seemed more dense, with the uncovered cells. This would increase transpiration in later years over the covered cells.

Cell 8 had the highest percent runoff of all the cells. This is because this cell was covered and because it was constructed in the second set, so experience gained in constructing cells 1 to 4 resulted in a smoother, more correctly sloped surface. Aside from this fact, the water balances for the two 8 ft cells (7 and 8) are reasonably close to their 4 ft counterparts, cells 4 and 1, respectively, until cell 1 was discontinued or the new lift was added to cell 4.

The increased amount of runoff obtained by applying soil cover was compensated in part by the decreased amount of evapotranspiration obtained by the use of cover, resulting in a mixed effect on the volume of leachate produced. In general, the cells without cover produced more leachate for the first year or two, but gradually produced less as a result of aging effects, resulting in less leachate during the later years. Using results from comparable cell pairs over the entire monitoring period, the effect of lack of soil cover on shredded refuse with the shallow cells was to decrease the amount of leachate by 23% (cells 2 and 4) but for the deep cells it was to increase leachate by 27% (cells 7 and 8). With shallow unprocessed refuse, the absence of cover decreased leachate production by 68% (cells 1 and 6). Comparing all covered cells (1, 2, 3, 8) and all cells without cover (4, 5, 6, 7), the covered cells produced 20.6% of the incident precipitation as leachate, while the cells without cover produced only 15.8%, both figures resulting from the entire period of monitoring. At first glance it appears that soil cover actually promoted leachate production, but this statement must be tempered by aging effects, and in this case by the results from the deep cells.

The water balance results for the covered cells in Table 1 are reasonable in comparison with published water balance data. Runoff coefficients for flat (0 to 5% slope) sandy loam with vegetation are quoted as 0.10 in reference (3), increasing to 0.30 for a clay and silt loam. Overall figures for the percentage of precipitation measured as runoff for the covered cells over the entire period of monitoring averaged 8.8%, including periods of freezing conditions. The agreement is satisfactory, considering the fact that the actual cover material is thought to have been somewhat finer than sandy loam, and that freezing conditions were included in the overall figures. The same reference indicates a general range in water consumption of 22 to 60 inches per year for "meadow grass", which is probably comparable to the mixed spontaneous vegetation arising on the cell surfaces. The average evapotranspiration rate for all cells over the entire period of monitoring was 23.5 inches per year.

Summary on Water Balance

In summary, it was the top surface of each cell which played a major role in determining the water balance for that cell. There was a direct relationship between whether or not a cell was covered and the percent of precipitation becoming runoff or evapotranspiration, where cover increased runoff, but decreased evapotranspiration by approximately the same amount. The percentage of precipitation becoming leachate also appears to have been related to the presence of cover, but the relationship is not that clear. Thus, for example, the unprocessed refuse cells with soil cover had approximately the same amount of leachate as the shredded refuse cells without cover, but the former had more runoff and less evapotranspiration than the latter, especially during the first few years of monitoring. As vegetation grew, and the refuse decomposed, the water balances for the shredded uncovered cells became similar to those of the unprocessed covered cells.

LEACHATE QUALITY

Many leachate analyses were performed on a routine basis for this project. In setting up a list of such analyses, it is natural to make a comprehensive list, multiplying the cost and labor requirements in the process. At the outset of this project, it was decided to limit the number of analyses to those felt to be most important in themselves, or most indicative of a class of substances which would be too time consuming to monitor separately. Of the analyses run routinely, three will be considered in some detail in this section. The COD will be used as an indicator of the organic content of leachate, the specific conductance as an indicator of the dissolved inorganic matter, and the pH will be considered primarily as it relates to the decomposition process. The other results will be deemphasized for this discussion, but will be presented in full for information purposes.

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It is important to note that all leachate samples were allowed to settle prior to analysis to avoid variations in quality due to sampling, and to approximate more closely the quality of leachate leaving a landfill where some filtering of solid matter would take place. A build-up of solids in the leachate collection reservoir led to variable amounts of solid matter in the samples depending on how the sampling hose happened to lay in the reservoir. Even though the reservoirs had provision for flushing of solids, a settling procedure in the laboratory was felt to be necessary to even the effect of variable solids contents in samples.

Interrelationships Between Curves and Initial Discussion of Cells 1-4

Prior to presentation and discussion of detailed leachate quality data, and discussion of changes in leachate quality as functions of shredding, covering, depth, and second lifts, it is useful to consider interrelationships between leachate volume and indicators of leachate quality. It is also useful to initiate discussion of the effects of shredding and soil cover by direct reference to these interrelationships and key data curves. To facilitate discussion of such interrelationships, Figures 7 through 10, combine the leachate volume, COD concentration, and pH data for cells 1 through 4, respectively. It would have aided the discussion to have included specific conductance data on these figures, also, but this would have made the figures too complex for easy reference. It is suggested that the reader refer to Figure 12 (to be presented later) if it is desired to refer to specific conductance curves in the discussion to follow. The fact that the shapes of the specific conductance curves are similar to those of the COD concentration curves will make direct comparison unnecessary for most readers at this time.

It is appropriate to first consider theoretical reasons for the relationships observed between the COD, specific conductance, and pH curves. The curve shapes correspond to a degradation seauence in which aerobic microorganisms initiate decomposition, producing CO_2, heat, and some products of decomposition. These products of decomposition are for the most part held within the refuse, for the refuse has generally not yet reached field capacity. As oxygen is exhausted, the first stage of anaerobic decomposition becomes dominant, in which facultative anaerobic microorganisms decompose organic matter to CO_2 and other products of decomposition, which include organic acids. The result is leachate of low pH containing large amounts of partially degraded organic matter. The COD rises, the pH falls, and in the process, inorganic matter is dissolved and the specific conductance is increased. When proper conditions exist, including no oxygen, reasonable pH levels, strongly reducing redox potential, reasonable temperature, adequate substrate and nutrients, lack of toxic substances, etc., second-stage anaerobic decomposition begins in which organic matter is more completely degraded to CH_4 and CO_2 and possibly some refractory organic compounds. This is accompanied by an increase in pH as organic acids are utilized, a reduction in specific conductance due to the pH change, and a decrease in COD as CH_4 is formed.

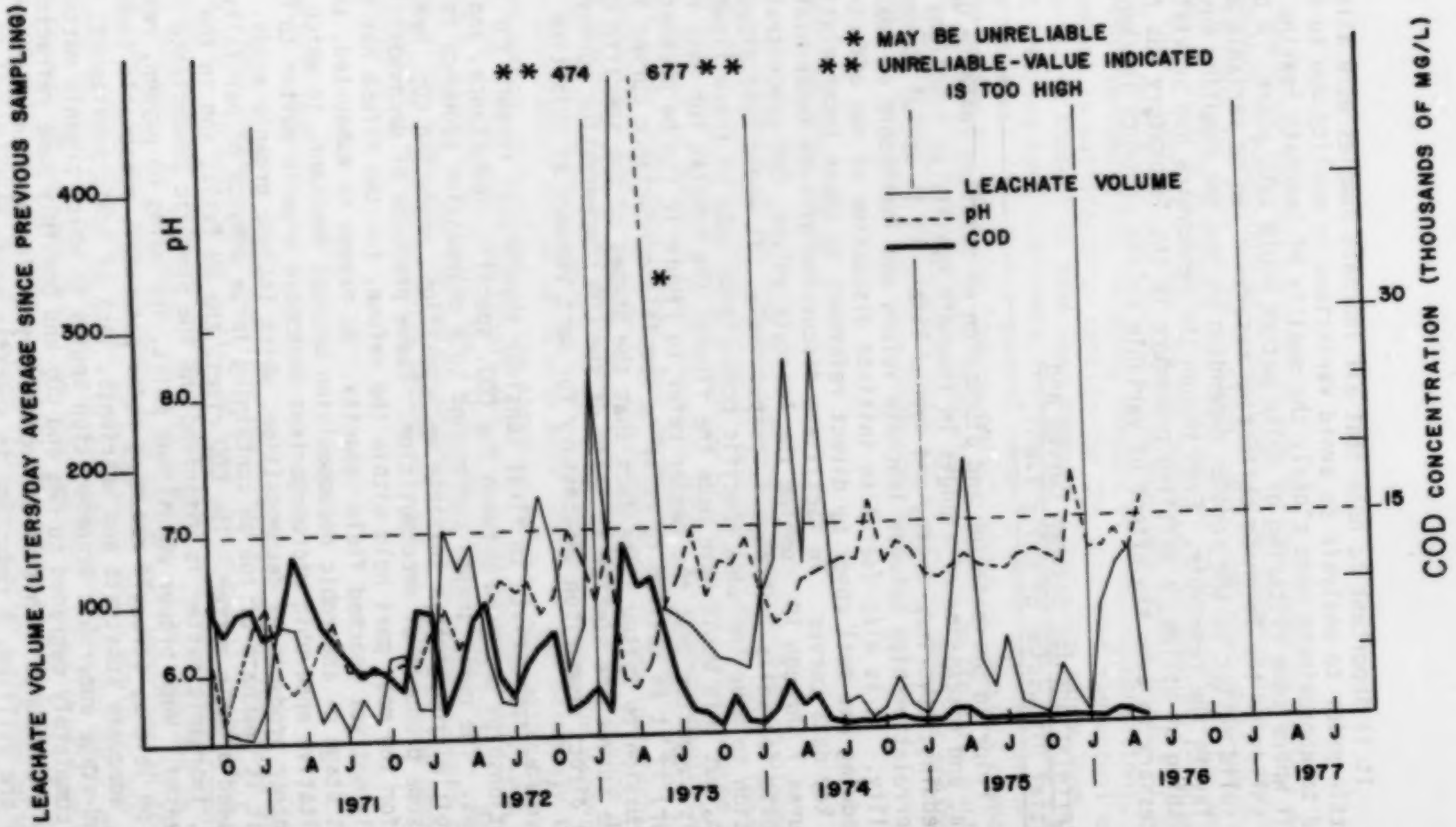

FIG.7 CELL I LEACHATE VOLUME - COD CONCENTRATION - pH

(NOT SHREDDED, COVERED IMMEDIATELY)

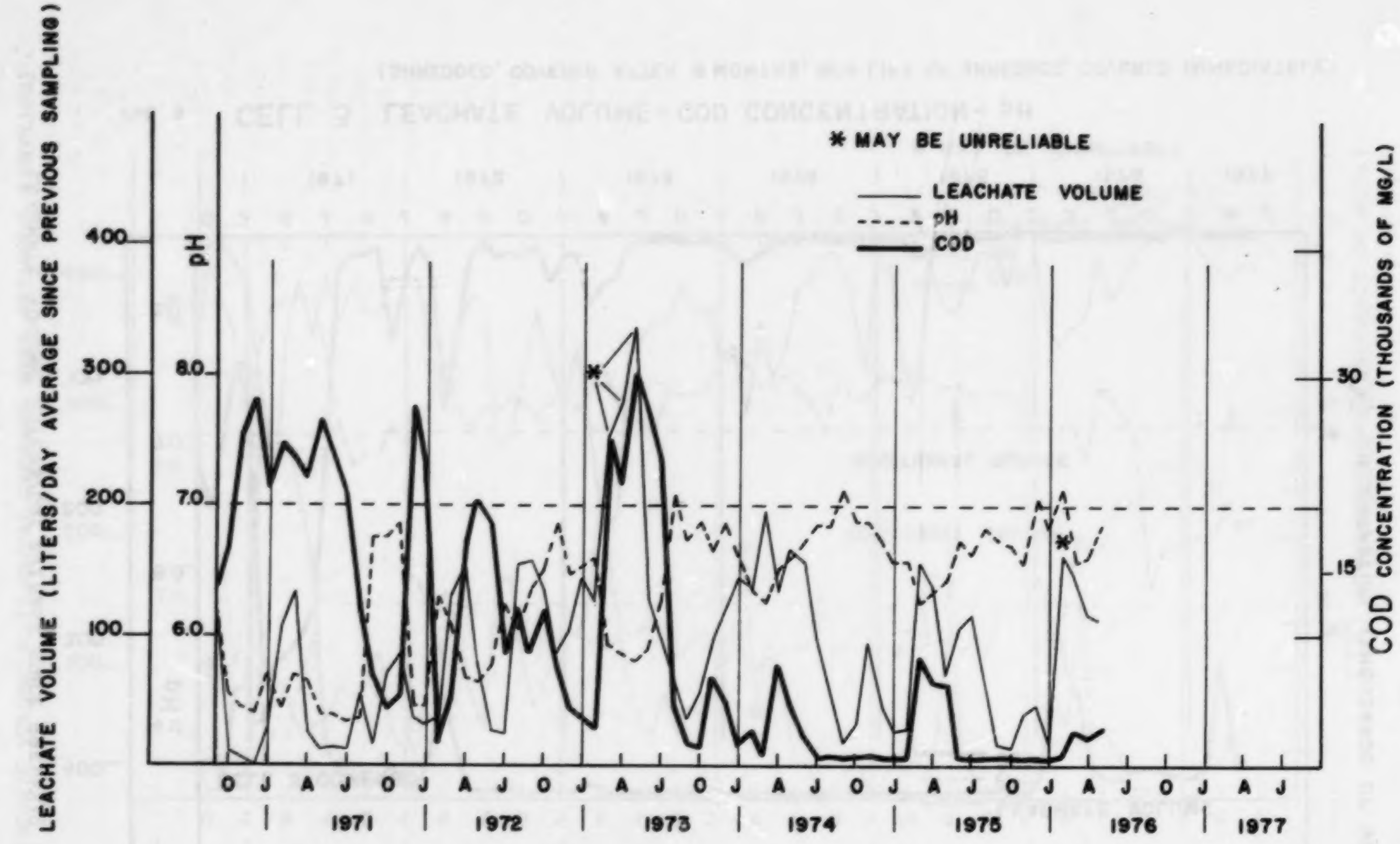

FIG. 8 CELL 2 LEACHATE VOLUME - COD CONCENTRATION - pH

(SHREDDED, COVERED IMMEDIATELY)

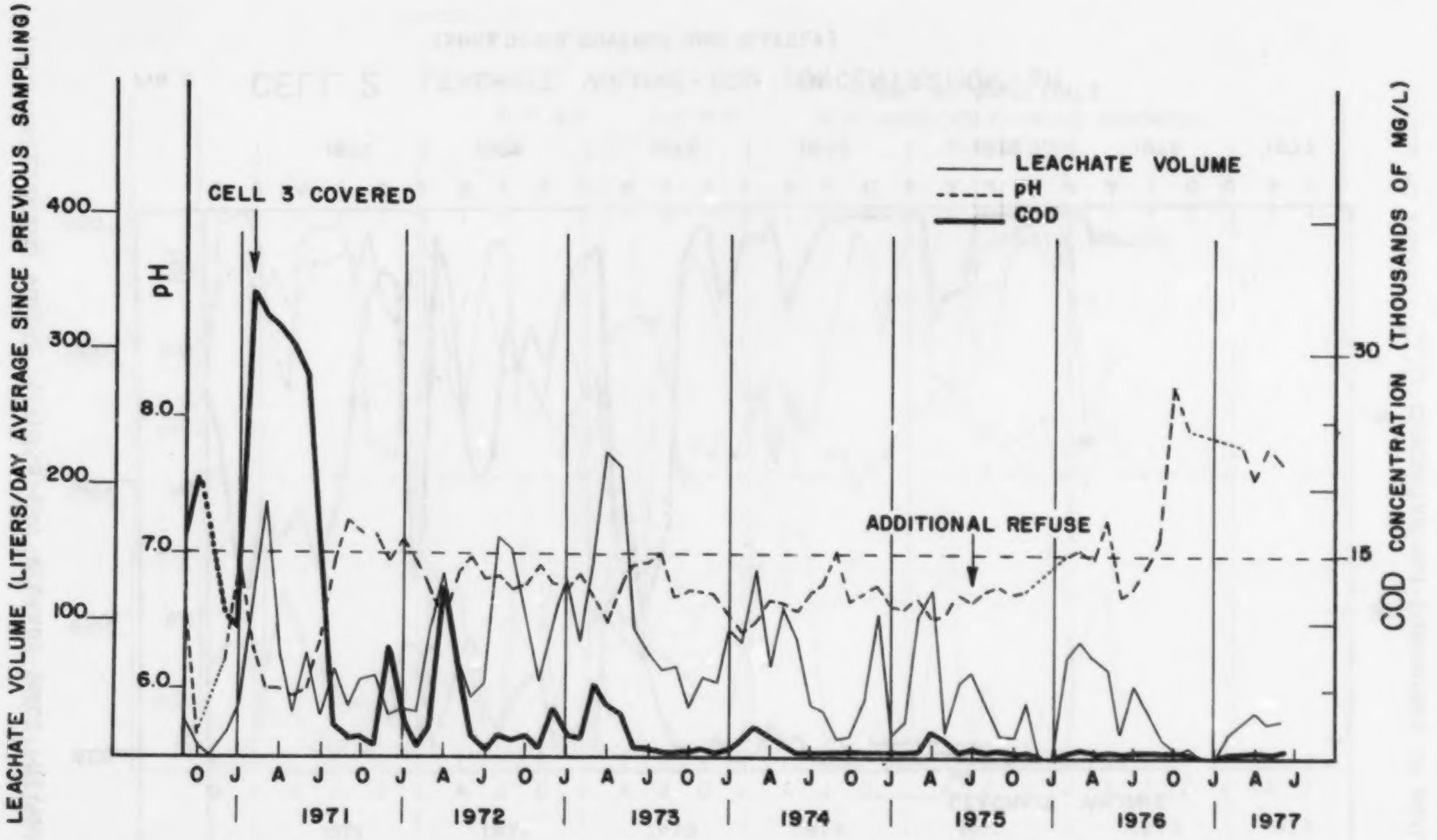

FIG. 9 CELL 3 LEACHATE VOLUME- COD CONCENTRATION- pH

(SHREDDED, COVERED AFTER 6 MONTHS, NEW LIFT OF SHREDDED, COVERED IMMEDIATELY)

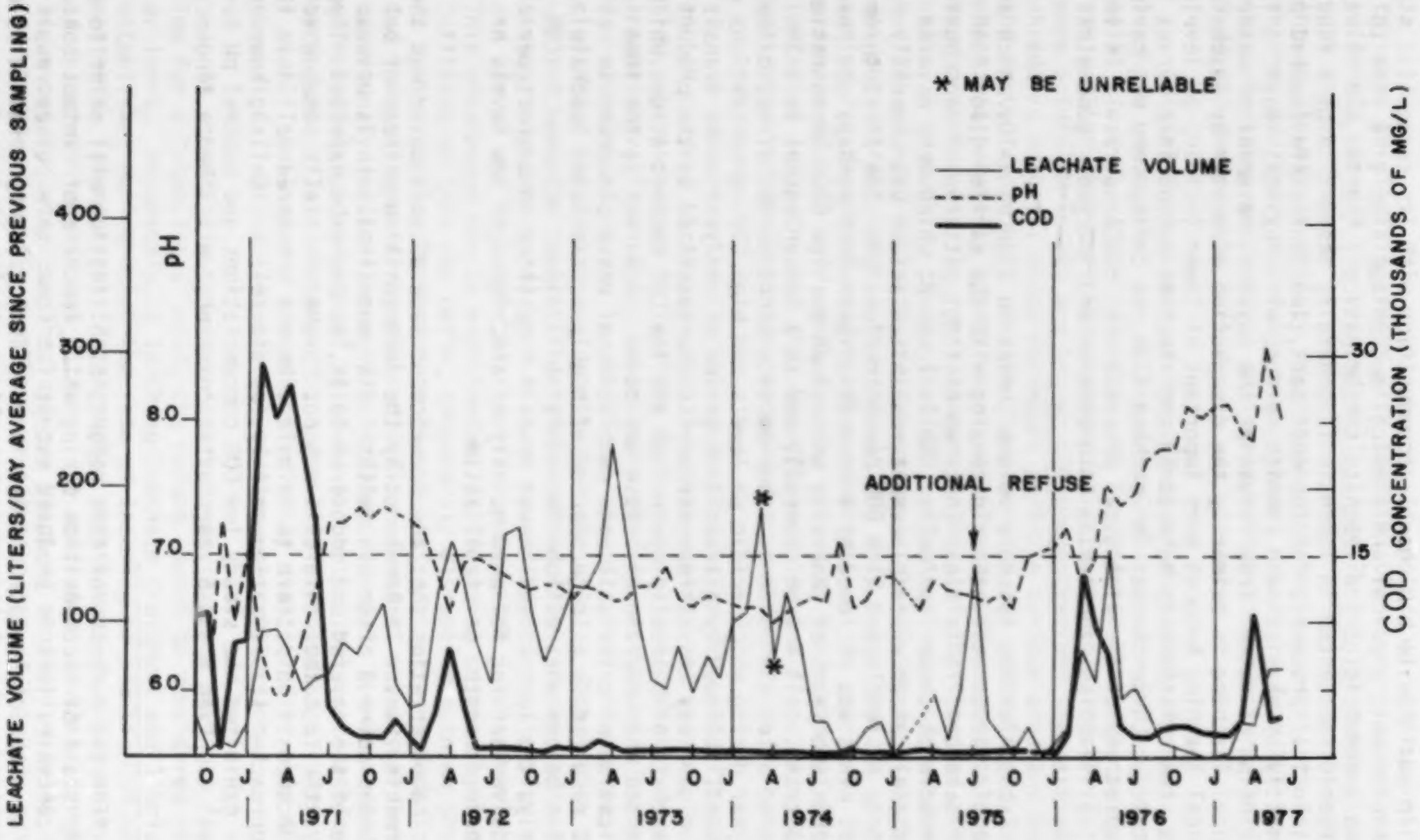

FIG. 10 CELL 4 LEACHATE VOLUME - COD CONCENTRATION - pH
(SHREDDED, NOT COVERED; NEW LIFT OF SHREDDED, NOT COVERED)

In addition to biological decomposition with its sequential stages of development, physical and chemical mechanisms also give rise to refuse decomposition and leachate contamination. Whereas the release of organic substances in leachate is generally thought to be a function of biological processes for the most part, inorganics are leached predominantly by physical and chemical processes. Physical leaching is the rinsing of matter from refuse by the physical movement of water. Chemical leaching is primarily the dissolution of matter by leachate. Chemical leaching becomes more important at lower (acidic) pH levels; hence, the relationship between pH and specific conductance curves is indicated. Large changes in leachate flow, as during very wet periods, can upset any of the biological processes but can also result in increased physical leaching, increasing both organic and inorganic concentrations in leachate.

Except for the leachate volume curves in Figures 7-10, which are quite similar to each other in keeping with the earlier discussion on water balances, it is clear that two distinct patterns of decomposition occurred with these four cells. Cells 1 and 2, which were covered immediately after waste placement, exhibited acidic but generally rising leachate pH levels and high COD concentrations over the first three years. This was followed by a transition period of perhaps one year and then two years of generally neutral pH and low COD concentrations. In contrast, cell 4 (not covered), and to a lesser extent cell 3 (covered after six months), experienced a short period of approximately one year during which acidic pH levels and high COD concentrations were produced, followed by a transition period of one year. The transition period gave way to a three-year period characterized by the production of leachate of basically neutral pH and low COD concentrations which was ended when additional refuse was added. Apparently, the immediate application of cover soil upon completion of waste placement in cells 1 and 2 resulted in a longer period of highly contaminated leachate production before what will be termed "stabilization" occurred.* Conversely, the lack of soil cover in cell 4 resulted in a short period of active leaching followed quickly by attainment of low levels of leachate strength, or stabilization.

The observation that the presence or lack of soil cover was the determining factor is borne out by the decomposition pattern of cell 3, which was covered after six months. Its general pattern is between those of the covered and uncovered cells, as might be expected. Apparently, the fact that this cell was not covered initially somehow set the decomposition pattern to be more like the uncovered cell 4 in that it approached stabilization quickly, as did cell 4. Cell 3, however, never exhibited the steady low COD concentrations and neutral pH levels of cell 4. Even 4 and 5 years after covering, cell 3 had a tendency to react to climatic events with elevated COD concentrations and acidic pH levels, as did the covered cells 1 and 2, but the curve fluctuations were not as dramatic as with cells 1 and 2. Cell 4, on the other hand, showed clearly an ability to withstand climatic events such as seasonal changes and heavy rainfalls with minimal departure from the low COD concentrations and neutral pH levels which characterized the leachate it produced during this period.

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*For the purposes of this report, stabilization will refer to a steady state of decomposition during which leachate of minimal contaminant concentrations is produced except for short term pulses resulting from an occasional major climatic event, such as a major rainfall, etc. This term does not imply that the solid waste is stabilized or inert, but that the degree of waste stabilization and the maturity of the decomposition processes are such that relatively uncontaminated leachate is produced.

Initial indications of the effect of shredding the solid waste on leachate composition are obtained by comparing the COD and pH curves of cells 1 and 2, Figures 7 and 8. It is observed that the curve shapes are similar, but that the shredded solid waste cell, number 2, exhibited more acidic pH levels and higher COD concentrations than cell 1. The shredding process, which increases particle surface area and homogenizes the waste, apparently resulted in a more highly contaminated leachate, which was generally approximately double the COD concentrations of the unprocessed cell. In considering all three of the shredded solid waste cells, 2 through 4, the typical COD concentrations achieved during the periods of most activity are generally in the 25,000 mg/l range, which was considerably higher than the 10,000 mg/l range typical of cell 1 during its period of active COD production. It is concluded that the presence of soil cover prolongs the period of production of highly contaminated leachate, and that shredding of the waste increases the concentration of the leachate produced during this period.

In comparing the leachate volume with the COD, specific conductance, and pH curves, it appears that leachate quality was related to leachate flow, where changes in leachate flow were followed quickly by changes in leachate quality. Thus, an increase in flow resulted in increased levels of contaminants in the leachate. In the late fall and winter, when precipitation was frozen and remained on the cell surfaces, high pH and low COD and specific conductance levels were common. Heavy rains in the spring and summer, and spring thaws caused high leachate flow rates, and low pH and high COD and specific conductance levels were observed. This phenomenon can be explained by oxygen being carried by heavy infiltration into the cells, temporarily disrupting methane production, or by the physical movement or flushing of partially degraded organic and inorganic matter by the rapid flow of water, thereby reducing the opportunity for treatment of materials present in the leachate. The effect of large amounts of rainfall is particularly noticeable in the spring of 1973 in the pH, COD, and specific conductance curves of cells 1 and 2. Cells 3 and 4 were sufficiently stabilized by this time to handle the rainfall with little effect on leachate composition.

It should be noted that just because leachate strength is relatively low for a "stabilized" cell, the refuse cannot be considered stabilized or inert. Apparently, a leaching-leachate treatment equilibrium is established during which the rate of leaching or addition of new organic matter to leachate passing through a refuse mass is balanced by the rate of decomposition of such matter. The concept of leachate treatment is borne out by data from the last two years of monitoring cells 3 and 4, for example, in which treatment or attentuation of leachate arising from new upper or second lifts by passage through the older, apparently well-stabilized lower lifts was observed. The lower lifts acted as trickling filters, able to treat or attenuate organic matter (COD) but not inorganic matter (specific conductance). This will be discussed in more detail later. The disruption of any leaching-leachate treatment equilibrium is one of the mechanisms by which leachate flow rate can affect leachate quality.

COD Concentration

The concentrations of COD for all eight cells are given graphically in Figure 11 and numerically in Table A-4. There appears to be a tendency on the part of all cells to produce higher COD concentrations during the later winter or spring. As discussed previously, this is a result of more water movement at such times due to winter thaws and spring rains, and to upsets in any biological equilibria established by water flow or temperature changes during these periods. The results from all eight cells support the conclusion reached in the previous section that shredded refuse produced leachate with higher peak COD concentrations than unprocessed refuse. In general, the 4-foot shredded refuse cells (2, 3, and 4) had peak COD concentrations of approximately 30,000 mg/l. The unprocessed refuse cells (1 and 6) had variable peak COD levels, where cell 1 peaked at approximately 15,000 mg/l and cell 6 had a one-sample peak of close to 30,000 mg/l but otherwise had considerably lower levels. Cell 5, with one-third shredded and two-thirds unprocessed refuse, had generally higher COD levels compared with cell 6 (unprocessed), and closely approximated cell 4 (shredded). Comparing peak COD levels of the two 8-foot deep cells, the shredded refuse cell 7 had a peak of 70,000 mg/l, while the unprocessed refuse cell 8 had peaks of approximately 30,000 and more mg/l. The trend is clearly for shredded refuse to produce leachate of approximately double the peak COD concentrations of comparable unprocessed refuse cells.

The effect of soil cover is observed by comparing cells 2 and 4 (shredded refuse) and 1 and 6 (unprocessed refuse). The application of soil cover increased markedly the period over which elevated COD concentrations in the leachate were produced. The difference became particularly obvious as the ages of the cells increased up to the time general stabilization occurred. Cell 3, to which soil cover was applied 6 months after construction, appears to correspond more to cell 4 which was never covered than to cell 2 which was covered immediately.

The uncovered cells (cells 4, 5, and 6) show high COD concentration values soon after the onset of leachate production, followed by rapid stabilization of the refuse or modification of leachate quality so as to reduce the COD to consistently low levels. The period of active leaching was less than a year in each case, excluding short periods of elevated but decreasing COD concentrations during subsequent years. The covered cells (cells 1 and 2, excluding cell 3 which was covered after six months) produced fluctuating COD concentrations which declined slowly over a period of 3 to 4 years to low, but not consistently low, levels.

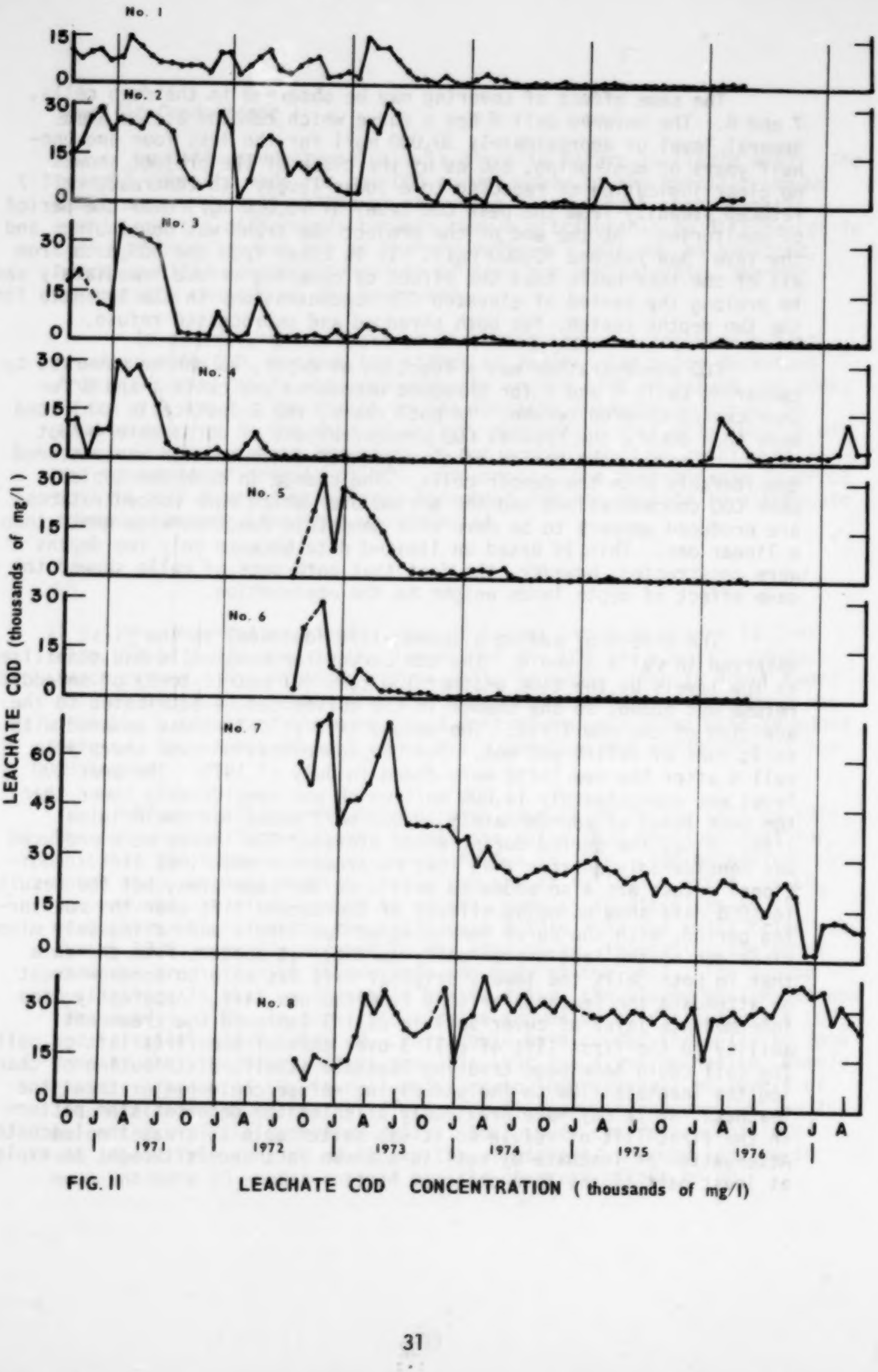

FIG. II LEACHATE COD CONCENTRATION (thousands of mg/l)

The same effect of covering may be observed in the deep cells, 7 and 8. The covered cell 8 has a curve which remains at tne same general level of approximately 30,000 mg/l for the last four and one-half years of monitoring, and as of the close of the project showed no clear indication of reducing to a lower level. In contrast, cell 7 reduced steadily from the peak COD level of 70,000 mg/l over the period of monitoring. At the end of the project the trend was continuing, and the level had reached 10,000 mg/l. It is clear from the COD data from all of the test cells that the effect of covering refuse immediately was to prolong the period of elevated COD concentrations in the leachate for the two depths tested, for both shredded and unprocessed refuse.

COD concentration was a function of depth, as can be observed by comparing cells 4 and 7 for shredded uncovered and cells 1 and 8 for unprocessed covered refuse. In both cases, the 8-foot cells exhibited more than double the typical COD concentrations of comparable 4-foot cells. Further, the period of elevated COD concentration was extended considerably with the deeper cells. The change in both the typical peak COD concentrations and the period over which such concentrations are produced appears to be more of a geometric function with depth than a linear one. This is based on limited data because only two depths were constructed; however, the fact that both sets of cells showed the same effect of depth lends weight to the observation.

The effect of adding a second lift identical to the first is observed in cells 3 and 4. The COD curves for both cells had stabilized at low levels by the time another 100 tons (91 metric tons) of shredded refuse was added, so any change in the curves can be attributed to the addition of the new lifts. The second lift of cell 3 was covered with soil; that of cell 4 was not. The COD concentration rose sharply in cell 4 after the new lifts were added in July of 1975. The peak COD level was approximately 14,000 mg/l which was considerably lower than the peak level of approximately 30,000 mg/l noted for the original lift. Also, the period during which elevated COD levels were produced was considerably shorter than that recorded for the first lift. Additional refuse was also added to cell 3 at the same time, but the resulting COD data show no major effects of the second lift over the monitoring period, with the curve remaining at low levels and having only minor rises during the last winter/early spring. It appears from the data that in both cells the lower, original lift was able to somehow treat or attenuate the leachate arising from the new lift. Apparently, the intermediate layer of cover soil in cell 3 improved the treatment ability fo the first lift of cell 3 over that of the first lift of cell 4. The soil could have been treating leachate itself, distributing or changing the leachate flow so the underlying refuse could better treat the leachate, or it may have previously affected the decomposition pattern in the first lift of refuse so it was better able to treat the leachate. Attenuation of leachate by soil is a known fact and is thought to explain at least part of the data observed here.

Specific Conductance

Specific conductance data is given in Figure 12 (Table A-5). The general comments made for the COD curves apply to the specific conductance curves as well, although the curve fluctuations with climatic events and the differences between curves attributable to differences in cell construction are not as sharply defined. This may be expected, since specific conductance values of zero are unattainable, thereby compressing changes at the lower end.

In general, the effects of shredding and covering were not as great as with COD, nor was the effect of depth. The major departure from COD curve trends occurred when the second lift of refuse was added to cells 3 and 4. The effect on the specific conductance curves is more pronounced in the case of cell 4, suggesting that attentuation of inorganics in leachate by refuse is not accomplished as readily as is the treatment of organic matter. Apparently, the intermediate layer of soil in cell 3 was particularly important for its ability to attentuate inorganic matter (specific conductance).

pH

As observed previously, the pH curves shown as Figure 13 (see also, Table A-6), vary as the inverse of the COD and specific conductance curves. The shredded refuse cells produced slightly lower (more acidic) minimum pH levels than the unprocessed refuse cells, which was probably a result of the more rapid initial decomposition with shredded refuse. The effect of soil cover was to prolong the production of low pH levels.

Of special interest is the sharp rise in pH in the fall of 1976. The only common factor shared by all the cells that could account for this was the extreme lack of precipitation in 1976. Two mechanisms by which these changes might be explained are as follows. First, as CO_2 is produced and rises upward to escape, some of it dissolves as it encounters water, making the cells more acidic. As the cells dried out during 1976, more CO_2 escaped to the atmosphere, increasing the pH of whatever precipitation flowed into the body of the cell. The second possibility is that as the cells became drier, the microorganisms became less active which, in turn, reduced the amount of acidic materials (CO_2 and volatile acids) produced. This could have caused the cells to lose some of their acidity. It is possible that the first mechanism, namely the dissolution of CO_2 in cell moisture to lower general pH levels of leachate, also explains the effect of soil cover in reducing pH levels below those of the uncovered cells. Soil cover can retain moisture and impair free venting of CO_2 to the atmosphere, thereby leading to more intimate CO_2-water contact and the observed effect on pH.

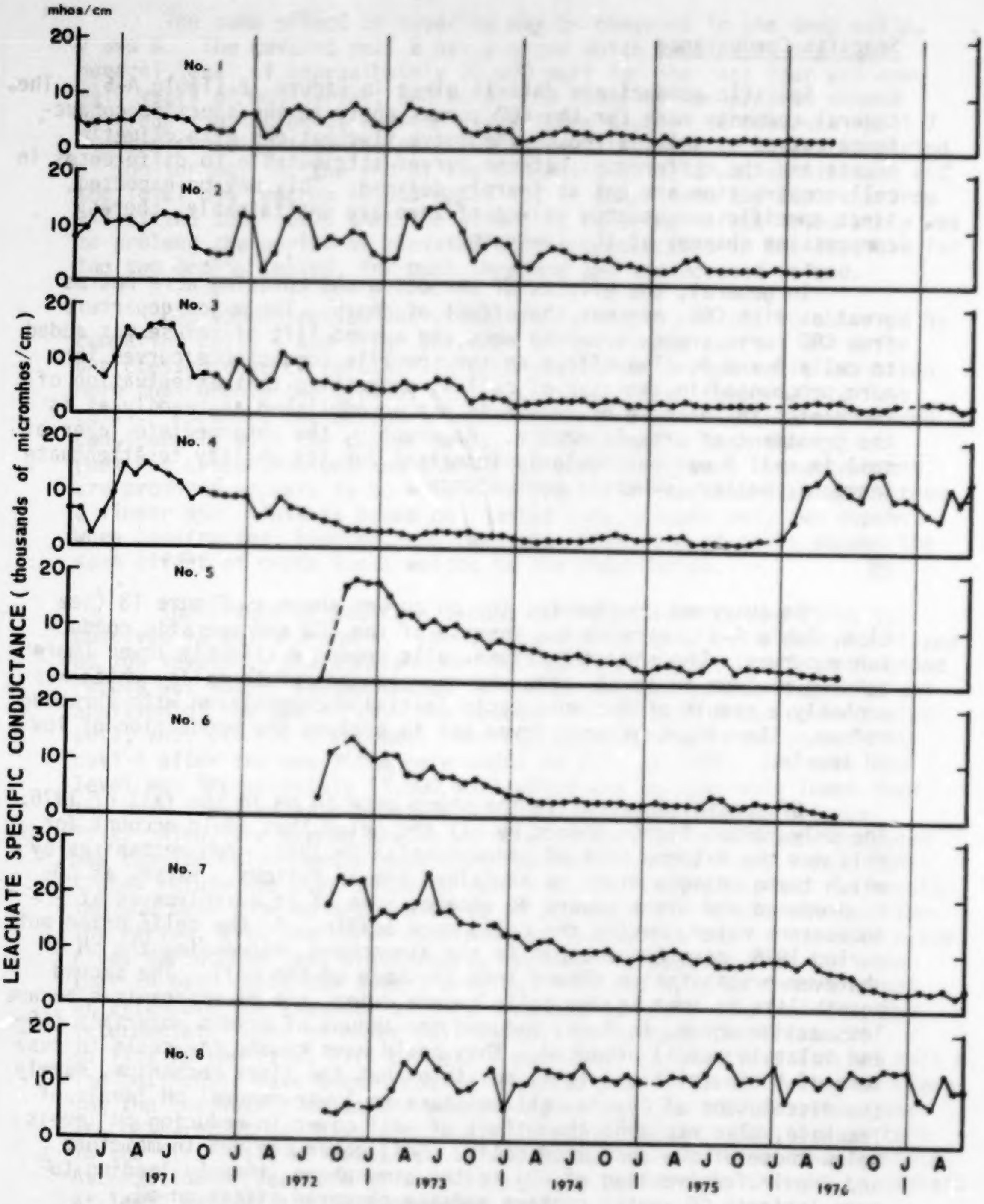

FIG.12 LEACHATE SPECIFIC CONDUCTANCE (thousands of micromhos/cm)

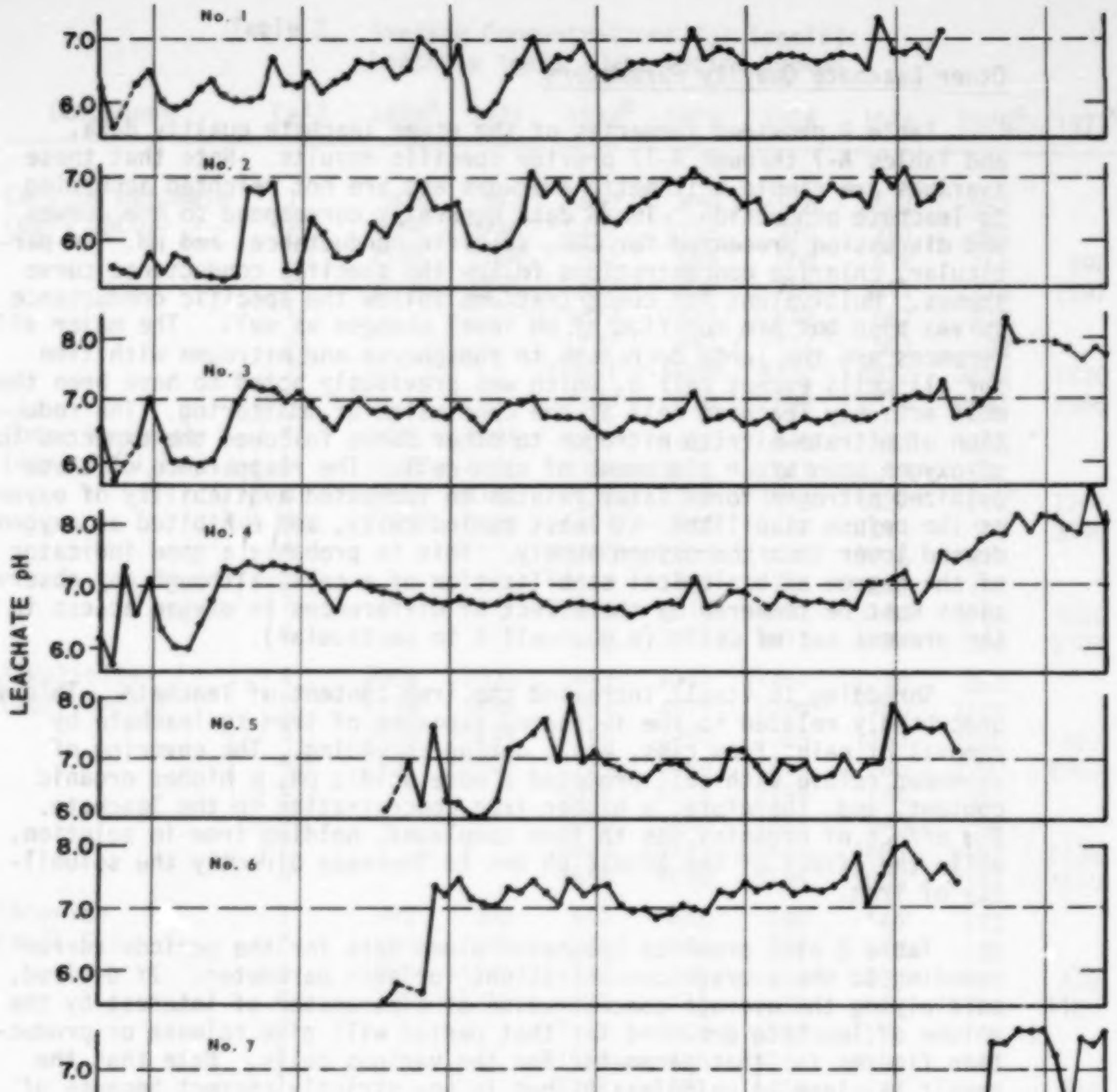

FIG.13 LEACHATE pH

Other Leachate Quality Parameters

Table 2 provides summaries of the other leachate quality data, and Tables A-7 through A-17 provide specific results. Note that these averages are simple arithmetic averages and are not weighted according to leachate production. These data generally correspond to the curves and discussion presented for COD, specific conductance, and pH. In particular, chloride concentrations follow the specific conductance curve shapes. Multivalent ion concentrations follow the specific conductance curves also but are modified by pH level changes as well. The major differences are the large decreases in phosphorus and nitrogen with time for all cells except cell 8, which was previously noted to have been the most actively leaching cell at the conclusion of monitoring. The reduction of nitrate-nitrite nitrogen to other forms followed the expected loss of oxygen soon after placement of each cell. The reapparance of these oxidized nitrogen forms later relates to increased availability of oxygen as the refuse stabilized, at least periodically, and exhibited an oxygen demand lower than the oxygen supply. This is probably a good indicator of the degree of biological stabilization of a cell, although any observations must be tempered by the effect of differences in oxygen access in the present set of cells (e.g., cell 6 in particular).

Shredding in itself increased the iron content of leachate. This is undoubtedly related to the increased exposure of iron to leachate by removal of paint from cans, etc., during shredding. The covering of shredded refuse with soil promoted a more acidic pH, a higher organic content, and, therefore, a higher iron concentration in the leachate. The effect of organics was to form complexes, holding iron in solution, while the effect of the acidic pH was to increase directly the solubility of iron.

Table 2 also provides leachate volume data for the periods corresponding to the average concentrations for each parameter. If desired, multiplying the average concentration of a parameter of interest by the volume of leachate produced for that period will give release or production figures for that parameter for the various cells. Note that the result is close to being exact, but is not strictly correct because of the way the averages were calculated.

Summary on Leachate Quality

In summarizing leachate quality data, the effect of shredding appears to be that of reducing particle size and mixing the refuse, thereby increasing the exposure of more of the refuse mass to active leaching or decomposition. The result was more rapid decomposition, as shown by higher COD and specific conductance, and lower pH levels during the period of elevated leachate strength. The effect of cover was to lengthen the period of elevated leachate concentrations. This effect is more difficult to explain, but one possible explanation is that the presence of cover may have caused more dissolution of CO_2 in infiltrating precipitation. This would have reduced the activity of CH_4 formers, which are progressively less able to function as the pH drops below 6 to 6.5. The result would have been a relative lack of methane formation,

Table 2. Average Concentrations for Specific Leachate tests (Over Period Shown)

Component	Cell	1970[a]	1971	1972[b]	1973	1974	1975	1976[c]	1977[d]
Calcium Hardness (mg/l $CaCO_3$)	1	908	813	803	873	568	501	862	
	2	4264	3298	2122	2156	920	791	996	
	3	2680	2784	832	689	599	616	758	998
	4	1518	1955	627	508	760	691	2374	1997
	5			1877	1377	843	857	818	
	6			1297	697	414	503	693	
	7			8981	6098	4584	3992	3653	1840
	8			3188	2298	2599	2618	3691	2866
Total Hardness (mg/l $CaCO_3$)	1	1636	1335	1377	1426	940	848	1436	
	2	5568	4375	2948	3271	1443	1213	1542	
	3	3932	4141	1632	1305	1014	1027	1272	1301
	4	2372	3432	1414	968	1096	1014	4403	3846
	5			3460	2508	1406	1216	1219	
	6			2119	1427	745	830	1160	
	7			12673	9013	5902	5196	6783	3652
	8			5088	3521	3911	4187	7360	5108
Alkalinity (mg/l $CaCO_3$)	1	2009	2037	2651	2332	1451	1148	865	
	2	5134	4496	3954	4579	2289	1700	1105	
	3	3855	5444	3140	2260	1355	1153	1240	971
	4	2451	5401	2724	1384	844	785	3909	2961
	5			6892	5076	2158	784	551	
	6			3980	3580	1222	540	346	
	7			10980	9741	5425	4806	4197	2138
	8			1558	4686	5135	5003	6164	4310
Chloride (mg/l Cl)	1	440	392	552	405	199	149	173	
	2	644	658	707	706	279	145	135	
	3	1056	1146	735	386	150	125	219	138
	4	725	1310	580	143	52	53	1470	1185
	5			1417	1140	393	176	149	
	6			1166	938	297	215	145	
	7			2387	1587	486	339	545	222
	8			447	817	848	903	1171	750
Iron (mg/l Fe)	1	70	85	120	175	125	93	150	
	2	296	430	381	581	192	183	216	
	3	138	384	138	99	101	90	55	122
	4	116	164	94	64	68	79	92	66
	5			92	109	83	54	21	
	6			94	29	31	10	14	
	7			719	739	1092	1130	1543	288
	8			71	275	434	487	688	320

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[a] September to December.

[b] August to December for Cells 4-8.

[c] January to May for Cells 1-2; January to June for Cells 5-6.

[d] January to June.

Table 2. (Continued)

Component	Cell	1970[a]	1971	1972[b]	1973	1974	1975	1976[c]	1977[d]
Ammonia-N	1	207	221	253	210	86	69	32	
(mg/l N)	2	322	271	275	335	144	59	24	
	3	249	374	190	125	52	58	66	42
	4	121	407	154	44	20	34	482	312
	5			909	580	173	34	14	
	6			622	340	42	3	4	
	7			966	716	337	173	108	64
	8			292	581	617	602	668	609
Organic-N	1	69	40	41	51	18	14	14	
(mg/l N)	2	124	112	65	118	32	19	13	
	3	166	144	39	30	19	18	12	12
	4	73	107	29	20	11	14	76	69
	5			167	127	29	12	15	
	6			174	66	19	18	16	
	7			978	647	183	115	57	36
	8			94	245	286	222	245	198
Ammonium-N	1	*	264	311	210	98	75	40	
(mg/l N)	2	*	348	262	339	151	74	26	
	3	*	550	147	138	58	66	65	41
	4	*	547	86	47	26	40	436	297
	5			897	605	183	41	18	
	6			629	353	53	12	7	
	7			746	734	355	206	186	61
	8			312	587	569	651	807	606
Nitrate-N plus	1	*	13.0	1.3	0.4	0.0	0.5	1.4	
Nitrite-N	2	*	11.3	0.1	0.4	0.0	0.5	0.1	
(mg/l N)	3	*	32.3	0.1	0.2	0.0	0.4	1.5	0.3
	4	*	31.7	0.1	0.7	0.5	0.6	18.2	14.9
	5			6.4	1.2	0.0	1.5	13.8	
	6			1.6	1.7	1.2	35.6	65.9	
	7			12.7	0.1	0.0	0.8	8.3	5.4
	8			2.2	0.1	0.0	1.5	12.2	3.5
Total Phosphate	1	49.8	28.0	12.7	7.8	4.0	3.5	2.2	
(mg/l PO_4)	2	49.0	31.2	6.7	8.3	3.9	2.9	2.2	
	3	51.0	20.0	4.2	4.2	2.8	3.4	1.9	1.1
	4	31.8	16.2	3.9	3.5	2.6	3.2	6.6	6.4
	5			34.2	21.1	4.5	2.6	1.9	
	6			106.2	38.5	8.6	5.1	4.4	
	7			103.2	44.8	22.9	29.8	22.9	7.4
	8			89.7	51.8	22.0	23.3	20.0	14.7
Soluble Phosphate	1	7.2	12.5	1.6	1.1	0.3	1.1	0.2	
(mg/l PO_4)	2	11.0	17.7	1.9	4.3	0.5	0.7	0.4	
	3	4.3	7.0	0.6	0.5	0.4	0.4	0.2	0.5
	4	4.2	5.9	0.7	0.3	0.4	0.5	1.3	1.3
	5			4.0	5.6	0.5	0.3	0.2	
	6			32.6	14.4	1.3	0.6	1.3	
	7			27.2	30.5	9.8	11.8	3.5	1.2
	8			11.4	34.2	13.9	9.5	4.9	5.6

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*No data.
(See footnote, previous page.)

Table 2. (Concluded)

Component	Cell	1970[a]	1971	1972[b]	1973	1974	1975	1976[c]	1977[d]
Leachate Volume (liters) —including March-May, 1973	1	2256	14536	35325	69296	33660	17182	10940	
	2	2313	18087	35905	50596	38308	24878	16084	
	3	920	24556	33228	36968	24310	15660	12817	4289
	4	1026	25271	39005	37332	23178	12329	14332	5652
	5			2146	35401	30552	7957	3929	
	6			2116	20933	13578	3736	2086	
	7			488	43055	37680	24919	33081	21297
	8			61	26010	31487	23897	30828	14502

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*(See footnote, previous page.)

continued acidic pH levels, and elevated COD and specific conductance (as affected by pH) levels. The CH_4 concentration data, to be presented later, will be seen to conform to this explanation.

Increased depth of refuse placed at one time increased the concentrations of contaminants in leachate and prolonged the period of production. In comparing the results from cell 7 (8 ft refuse, one lift) and cell 4 (same amount of refuse, 2 lifts), both shredded refuse without cover, it is possible that the amount of material present in the leachate in cell 7 was simply too much (too acidic, probably) to allow active methane formation. Thus, it may have been the cumulative amount of actively decomposing material present in deeper cells landfilled at one time which prevented maturation or stabilization of the decomposition processes taking place in the refuse.

PRODUCTION OF CONTAMINANTS IN LEACHATE

The concentrations of the various contaminants are not as important as the amounts of each contaminant in affecting ground or surface water quality. In Figure 14 (Table A-18), the leachate production rates and COD concentrations are combined to give the COD production rates as the average grams of COD produced per day since the last sampling. As mentioned previously, Table 2 can be used to calculate similar production figures on a yearly basis for other leachate parameters.

The COD production rate is observed to be very seasonal, with peaks in the late spring, similar to the leachate production rate. Shredding appears to promote a higher production of COD when compared with otherwise similar unprocessed refuse cells. The uncovered cells peaked with respect to COD production within a year and tapered down to very low COD production rates except for cell 7, the deep cell without cover. Cell 7 is declining in its COD production rate over time, but not at such a rapid rate. This is apparently due to the influence of depth as discussed previously. The covered cells seem to have fluctuated more in COD production rates than the uncovered cells. This is especially true after the first year. The deep cells (cells 7 and 8) had very high COD production rates and fluctuated widely over the testing period. This is due to the strong influence of the high COD concentrations of the deep cells.

In Table 3, the leachate volume and COD concentration data are combined to give the kilograms of COD produced by each cell over the specified periods of time. Because of the water balance problems from March through May of 1973, as discussed earlier, the data in Table 3 is presented in such a way as to both include and exclude this period. Cells 1 through 6 have all declined sharply with respect to COD production, but the rate of decline varies from cell to cell. Cell 4 had a significant increase in COD production after additional refuse was added to it in 1975. However, cell 3 did not exhibit such a change under similar circumstances. Cells 7 and 8 show very high production of COD for the entire reporting period.

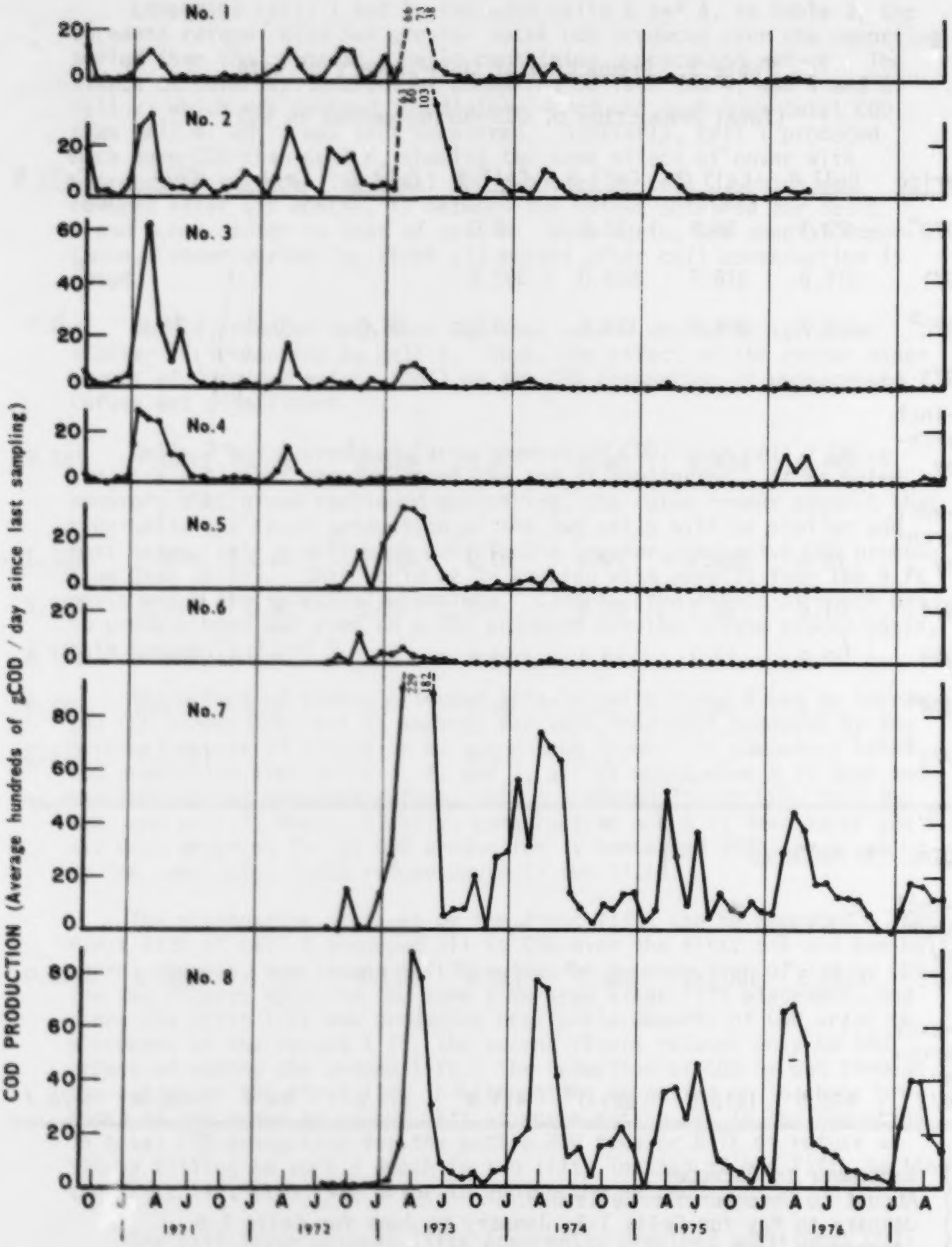

FIG.14 COD PRODUCTION (g.COD / day average since last sampling)

Table 3. Production of COD—Summary of Data

(Total Production of COD during period in kg)

Period	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
1970[a]	22.1	34.6	13.8	8.0				
1971	116.8	318.7	503.0	302.6				
1972[b]	199.7	394.3	116.9	89.0	56.0	50.7	26.8	0.7
1973								
—incl. March-May	594.3	854.6	86.0	24.6	455.3	65.9	2240.1	752.6
—excl. March-May	75.6	264.4	19.2	10.2	187.2	33.1	668.7	182.3
1974	61.8	95.7	23.9	7.0	55.2	8.0	1091.2	969.7
1975	12.0	77.1	13.1	4.6	4.3	1.7	626.1	657.8
1976[c]	7.5	28.0	5.7	89.8	1.1	0.9	674.8	852.9
1977[d]			1.4	19.3			201.3	415.3
TOTAL COD PRODUCED								
—incl. March-May 1973	1014.2	1803.0	756.7[e]	435.8[e]	571.9	127.2	4860.3	3649.0
—excl. March-May 1973	495.5	1212.8	689.1[e]	421.4[e]	303.8	94.4	3288.9	3078.7

a) September to December
b) August to December for Cells 5-8.
c) January to May for Cells 1-2; January to June for Cells 5-6.
d) January to June.
e) Excludes period beyond December 1975, after which effect of second lift was observed. From January 1976 to end of project, these cells produced: 7.1 kg COD for Cell 3; 109.1 kg COD for Cell 4.

Comparing cells 1 and 2, and also cells 6 and 4, in Table 3, the shredded refuse cells had greater total COD produced over the reporting period than the comparable cells containing unprocessed refuse. The effect of cover is observed by comparing cells 2 and 4, and 1 and 6. Cell 2, which was covered immediately, produced much more total COD than cell 4, which was left uncovered. Similarly, cell 1 produced much more COD than cell 6, showing the same effect of cover with unprocessed refuse. The total COD produced by cell 3, which was covered after six months, is between the values obtained for cells 2 and 4 but closer to that of cell 4. Once again, the special importance of cover during the first six months after cell construction is noted.

Cell 6 produced much less COD than cell 5 which, in turn, was similar in production to cell 4. Thus, the effect of the rather minor amount of shredded refuse (30%) on the COD production of unprocessed refuse was significant.

Cells 7 and 8 produced large amounts of COD, with cell 7 being the more active of the two as of the end of monitoring. It is noted, however, that given continued monitoring, the curve trends suggest that eventually the total production of the two cells will be similar and that later, cell 8 will have exhibited a greater cumulative COD production than cell 7. This would be in keeping with results from the 4 ft cells which are relatively complete. Clearly, the effect of depth was to produce more COD even on a COD produced per ton refuse placed basis, both for cells 7 and 8.

The effect of adding a second lift to cells 3 and 4 was to increase the COD production, but in amounts far less than that produced by the original layers of refuse or by one 8-foot layer. In comparing total COD production from cells 3, 4, and 7, all of which were 8 ft deep and had 200 tons of shredded refuse, cell 3 produced 757 kg COD, cell 4, 436, and cell 7, 4860. Clearly, constructing one 8 ft deep layer (cell 7) was much worse as far as COD production is concerned than constructing to the same total fresh refuse depth in two lifts.

The attenuation achieved by the first lifts can be computed. The first lift of cell 4 produced 311 kg COD over the first one and one-half years, whereas, the second lift resulted in a production of 109 kg COD. The two figures apply to the same time span after lift placement, and since the first lift was producing negligible amounts of COD prior to placement of the second lift, the second figure relates only to the effect of adding the second lift. The reduction of COD by 65% through the action of the first lift in attenuating or acting on leachate produced in the upper or second lift is worth noting, as is the reduction in total COD production for the entire 200 tons or 8 ft of refuse of 91% by filling to such a depth in two lifts instead of one lift, letting the first lift stabilize prior to adding the second.

The soil layer between lifts apparently provided additional COD removal or attenuation capacity beyond that of just shredded solid waste. Without a soil layer, cell 4 COD production from the first lift of 311 kg was reduced to 109. For shredded refuse covered immediately, cell 2 produced 353 kg COD which would represent the first lift results had cell 3 been covered immediately. Production from the second lift of cell 3 was only 7.1 kg COD, for a reduction of 98% through the action of the first lift with its soil cover in attenuating COD produced from the second lift. It appears that construction of shredded refuse landfills in thin lifts, specifically not using cover immediatley on at least the first lift but adding it prior to construction of the second lift, and allowing the first lift to stabilize prior to subsequent filling, should be further investigated.

It is difficult to justify looking at either the production figures, including March-May, 1973, or specifically to exclude that period of very heavy rainfall. The proper figures are probably somewhere between the two, for larger amounts of rain are normal during the spring, yet not as much as occurred in 1973. It is interesting to note the effect of the heavy rains on the cells, however. Cells 3, 4 and 6 (but especially cells 4 and 6, both uncovered) were fairly stable at this time and were able to tolerate the heavy rains with little effect on COD production. In contrast, cells 1, 2, 7, and 8 were not so stable and had been producing significant amounts of COD prior to the heavy rains. When the heavy rains came, these cells further indicated their instability by producing greatly increased amounts of COD. This was especially true of cell 1. It may be that during the stage of decomposition in which significant amounts of contaminants in leachates are produced, refuse is particularly susceptible to upset through changes such as increased infiltrations rates. Certainly, the ability to withstand large amounts of rainfall without producing large amounts of COD is desirable. This may prove to be of significant value in landfill design in years to come, and be one particularly interesting characteristic of shredded refuse without daily soil cover.

Production figures for various other species determined in the leachate can be calculated, if desired, from data given in Table 2. Typically, the comments regarding COD production apply to the other species as well.

GAS COMPOSITION

Gas composition data is presented in Figures 15, 16, and 17 (Tables A-19, 20, and 21) as the averages of the compositions observed at 2 and 4 ft depths in the 4 ft cells and 3, 5, and 7 ft depths in the deep cell.

Oxygen

Oxygen was depleted rapidly in all cells and remained at low levels for most of the reporting period. Major exceptions to this occurred during periods of heavy infiltration (large rainfalls such as March-April, 1973, or thawing conditions), when oxygen was evidently carried into the cells by water flow, and during cold weather when increased oxygen solubility in water and/or decreased biological activity led to increased oxygen concentrations.

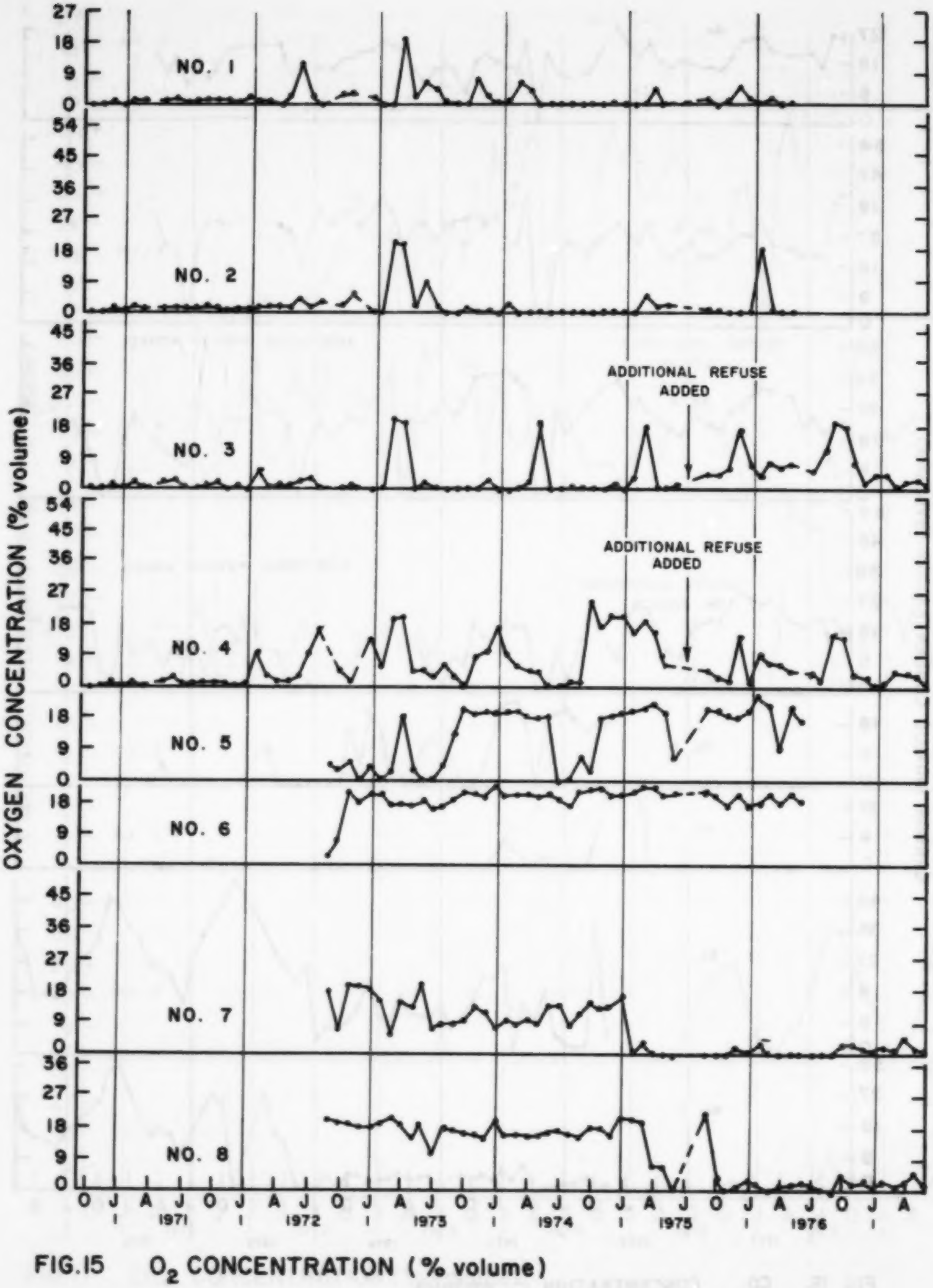

FIG.15 O_2 CONCENTRATION (% volume)

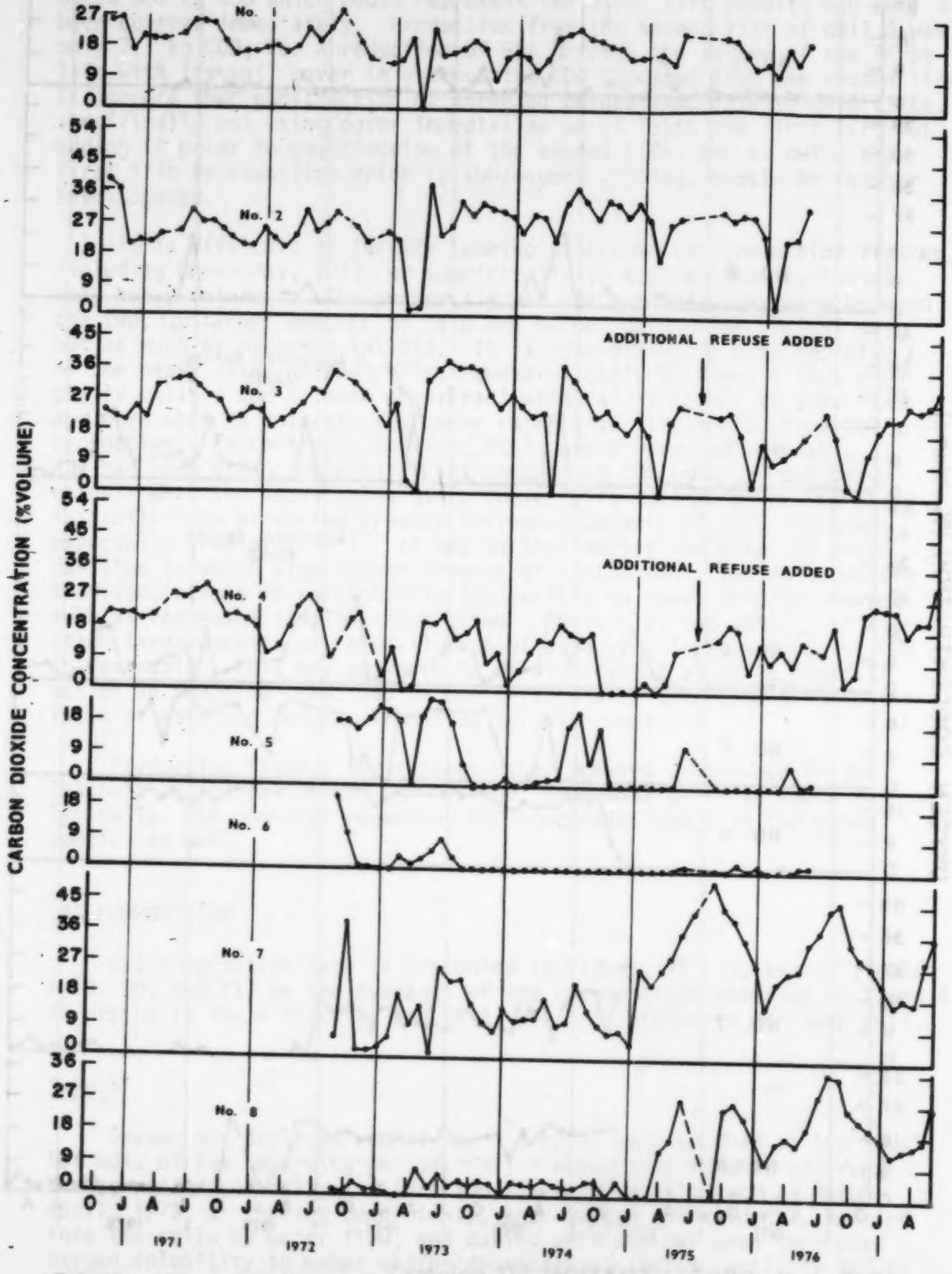

FIG. 16 CO_2 CONCENTRATION (% VOLUME)

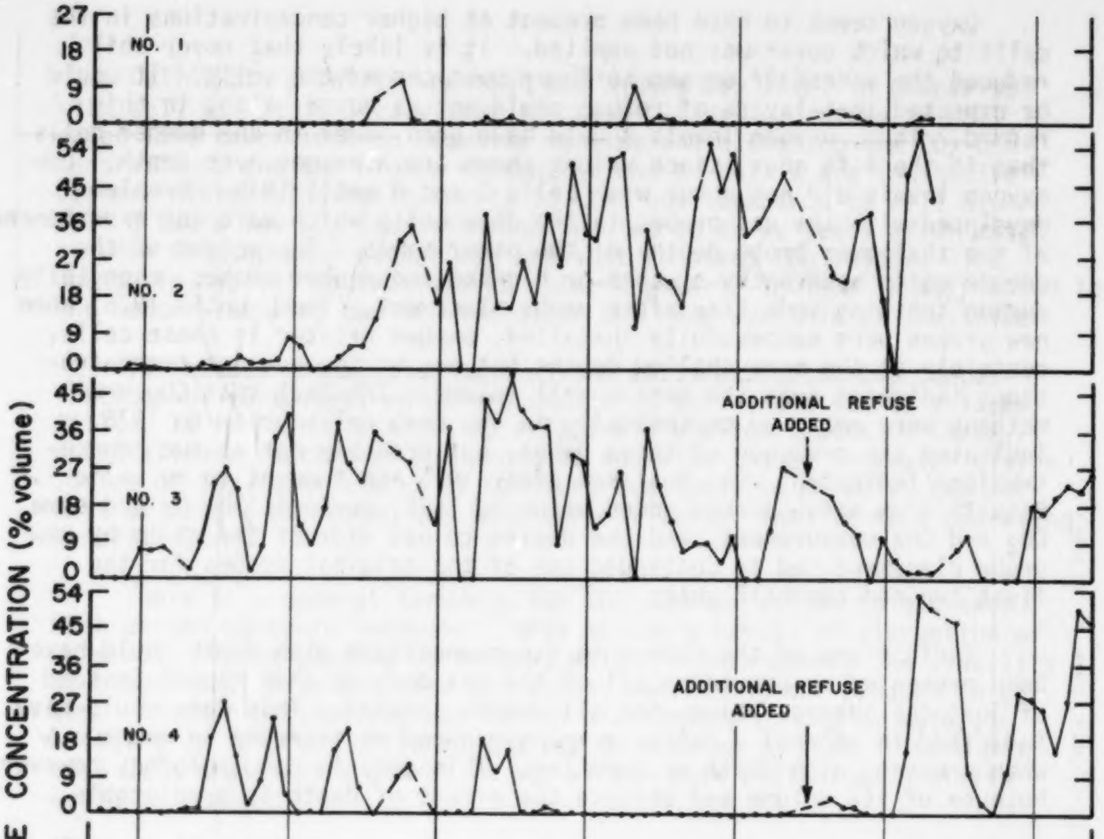

FIG.17 CH_4 CONCENTRATION (% volume)

Oxygen seems to have been present at higher concentrations in the cells to which cover was not applied. It is likely that cover soil reduced the access of oxygen to inner portions of the cells. It would be expected that layers of refuse could act as cover, also, in this regard. Thus, oxygen levels should have been lower in the deeper cells than in the 4 ft ones, since values shown are averages over depth. Low oxygen levels did not occur with cells 7 and 8 until 1975. Problems developed with the gas probes in the deep cells which were not experienced at the shallower probe depths of the other cells. The weight of the deeper cells apparently crushed or blocked the deeper probes, especially during settling some time after probe placement. Thus, until 1975, when new probes were successfully installed, oxygen existed in these cells, certainly at the more shallow depths but not at the average concentrations indicated over the entire cell volume. The fact that CO_2 and methane were measured periodically in the deep cells prior to 1975 indicated the presence of these gases, but probably not at the concentrations indicated. Gas analyses after 1975 are thought to be valid. Results from extra probes added prior to 1975, periodic low O_2 and some CO_2 and CH_4 measurement, and the desire to not disrupt the cells by new probe placement led to continued use of the original probes for the first two and one-half years.

Indications of the change in gas composition with depth could have been presented by providing all of the gas data in this report instead of just the average values for all depths sampled. This data would have indicated in general a decrease in oxygen and an increase in methane, when present, with depth of sampling. This data is not included, however, because of its volume and because the effect of depth is predictable.

Oxygen is seen to have been measured frequently in small amounts since the beginning of monitoring. It is likely that small levels are insignificant, and that oxygen was introduced during sampling and analysis. Theoretically, oxygen and methane could not occur together, because the manufacture of methane takes place only in the absence of oxygen. In many cases, however, replicate samplings, or comparison with the known nitrogen/oxygen ratio of air leakage, indicated that oxygen and methane did, in fact, co-exist, at least periodically. It is likely that pockets of anaerobic conditions led to localized methane production even though other portions of the refuse mass had small amounts of oxygen because of infiltration of oxygen through voids or transport of oxygen via incoming moisture. These pockets of anaerobic activity apparently grow and retreat, depending on the local situation, becoming predominant during periods when a refuse mass can be classified as predominately undergoing methane formation.

CO_2

The CO_2 levels were fairly constant for cells 1, 2, and 3. Cell 4 shows more variation in CO_2 concentration and generally lower concentrations than cells 1, 2, and 3. Cells 5 and 6 had very little CO_2, especially after the first year. Apparently, the lack of cover soil typically reduced the CO_2 content in cells 4, 5, and 6. This was probably due to the relative ease of gas venting in the absence of cover soil.

Cell 7 had a fairly constant and higher CO_2 level in comparison with cell 8. It is likely that the upper layers of refuse in cell 7 acted like cover soil in reducing venting and elevating the CO_2 concentrations, and the higher concentrations of cell 7 are indicative of more microbiological activity in that cell compared to cell 8. Cell 8 had a low CO_2 concentration for two to three years after which it rose to generally higher and somewhat constant CO_2 levels. The change in typical concentrations occurring early in 1975 is attributed to the better sampling devices installed and made operable at that time.

It is interesting that none of the cells exhibited CO_2 concentrations of 45 to 50%, which are common in full-scale sanitary landfills. It is possible that the relatively shallow depths of these cells allowed venting of CO_2 produced and also led to increased dissolution of CO_2. The amount of moisture available to dissolve CO_2 per unit of weight of refuse was considerably larger than in most operating landfills.

There is a general tendency for CO_2 concentrations to decrease when oxygen contents increase. This may be a result of disruption of anaerobic microorganisms by oxygen, which in turn upsets the stability of predominant decomposition processes, decreasing the production of CO_2. Another possibility may be the dissolution of CO_2 by water, bringing O_2 into the cells during wet or thawing periods. There may also be a temperature effect in the winter when biological activity would be reduced.

It is generally difficult to place much significance on CO_2 gas concentration data alone, because a concentration measured at a point is the combined result of biological CO_2 production, gaseous CO_2 transport out of the refuse mass, and solubility of CO_2 in available moisture. CO_2 is readily soluble in water, so one might expect decreased concentrations in the gas when large amounts of water are flowing through a refuse volume. By comparing CO_2 concentration results to precipitation, leachate volume, or any of the leachate quality parameters previously shown to be related to leachate flow (as COD), it is noted that increased leachate flow rates are normally accompanied by decreased CO_2 concentrations.

CH_4

Methane production, indicating anaerobic conditions somewhere within a cell, is seen to have occurred more quickly and resulted in higher concentrations within the shredded cells (cells 1 (unprocessed) vs 2, 3, and 4; cells 6 (unprocessed) vs 5 (two-thirds unprocessed, one-third shredded); and cells 8 (unprocessed) vs 7. Undoubtedly, the mixing and reduction in particle size which took place during shredding led to rapid oxygen utilization and depletion, leading eventually to methane production. A comparison of cells 5 and 6 is particularly interesting in this regard for even though cell 5 contained only one-third shredded refuse, and this material was at the surface of the cell, cell 5 had more CH_4.

The covered shredded cells (2 and 3) had the highest methane concentrations, probably because the cover limited the outflow of methane and inflow of oxygen and nitrogen. The 4 ft uncovered shredded cells (4 and probably 5) produced some methane quickly, after which their methane concentrations were uneven or sporadic. Fluctuations during the later period were probably due to periodic increases in oxygen availability or CH_4 production with precipitation events and seasonal temperature changes. The lower CH_4 concentrations observed during the last four years are probably a result of increased O_2 availability brought about by prior utilization of the readily decomposible fractions of the refuse.

The unprocessed refuse cells (cells 1, 6, and 8, and to some extent, 5) produced very low methane concentrations throughout the period of monitoring.

The effect of depth on the methane formation decomposition patterns of a cell is readily observed by comparing cells 7 and 8 with their shallower countercells. In keeping with leachate quality data, the deep cells did not produce CH_4 until much later than comparable 4 ft cells (cells 7 and 8, deep, vs 4 and 1, shallow). The prolonged period of high COD and acidic pH levels in the leachate from the deep cells correspond to a lack of CH_4 present in the gas.

The effect of cover was a combination of increasing CH_4 concentrations by reducing free venting to the atmosphere of whatever gas was generated, and reducing CH_4 production rates through mechanisms discussed previously with regard to pH and COD changes in leachate quality with time. It is impossible to determine the true effect of cover soil in CH_4 production because no gas production data could be gathered from these test cells. Consequently, changes in CH_4 concentration cannot be strictly related to CH_4 production, and the true effect of cover on CH_4 production can only be discussed in general terms by interpretating all of the available data for each cell as a basis for discussion.

The effect of adding a second lift to cells 3 and 4 was to increase the CH_4 concentration in cell 4 and to decrease it in cell 3. With cell 4, the second lift provided new substrate for CH_4 production and acted as cover soil in retarding venting of that CH_4. The result was relatively high CH_4 concentrations after the second lift was added. In the case of cell 3, the CH_4 concentrations decreased when the second lift was added. The reason for this effect is not known, for the pH levels and low COD production rates during this period suggest that anaerobic fermentation is occurring, and that CH_4 production could be expected. The CH_4 concentration was rising at the conclusion of monitoring, so perhaps the period of low CH_4 concentration after the second lift was added was a transitional or lag period similar to that experienced initially by all of the cells which were covered immediately. The CH_4 concentration curve for cell 3 after the second lift was added does look like the early portions of the curve for cell 2 (covered immediately, as was the second lift of cell 3). The major difference is that high pH levels and substantial COD concentrations typified the leachate from cell 2 during the period of low CH_4 concentrations, which was not the case for the second lift of cell 3.

Periods of peak CH_4 concentrations generally occur during the summer with all cells. This may be due to precipitation rates, but undoubtedly also relates to the warmer temperatures during the summer which are more conducive to methane formation.

Summary on Gas Composition

One has to be extremely careful in interpreting the gas composition data. The values obtained can be a result of production of CO_2 or CH_4, gaseous transport of CO_2 and CH_4 outward or oxygen and nitrogen inward, or solubility effects. There is no way to distinguish one from the other in this situation. It may be possible at a later date to develop diffusion coefficients, using nitrogen as a basis since it is not involved in the decomposition processes, to give insight into the effect of diffusion on the resulting gas compositions.

In summarizing the effects observed in all of the gas data, apparently the effect of cover soil is to increase the concentration of methane, decrease oxygen content, and to postpone active methane production to a later date. Part of the effect of cover is certainly a result of reduction in venting of decomposition gases outward and oxygen inward, but part of it is also likely a change in the decomposition processes within the refuse to postpone rapid methane formation. The methane curves relate well to the leachate quality curves, underscoring the lack of methane formation under acidic conditions, and the reduction in COD when significant methane formation occurs. Additional discussion in this area was given in discussion of leachate quality data.

Shredding promoted higher methane concentrations and the production of methane quickly after cell construction. This is a result of mixing and particle size reduction, as discussed earlier. The deep cells had little or no methane formation until much later in comparison with their respective shallow cells. This also corresponds with leachate quality data and indicates the substantial effect of depth in slowing or retarding the formation of methane with the attendant beneficial improvement of leachate quality. The placement of new lifts of refuse on cells 3 and 4 resulted in temporary increases in oxygen followed by substantial increases in methane and, to a lesser extent, CO_2 concentrations. This was a result of oxygen emplaced with the refuse, upsets in the decomposition processes taking place in the lower lifts after the second lifts were placed, and the readily decomposed matter landfilled with the second lifts.

REFUSE TEMPERATURE

Average refuse temperatures are given in Figure 18. These values were computed by averaging all temperatures measured by three sets of probes, each set consisting of three probes, located approximately one-half, two and 3 and one-half ft below the surfaces of the 4 ft cells. Four sets of probes were located at the 1, 3, 5, and 7 ft depths in the 8 ft cells. Probes were placed in triplicate to allow averaging of readings and so that clearly erroneous readings could be justifiably omitted.

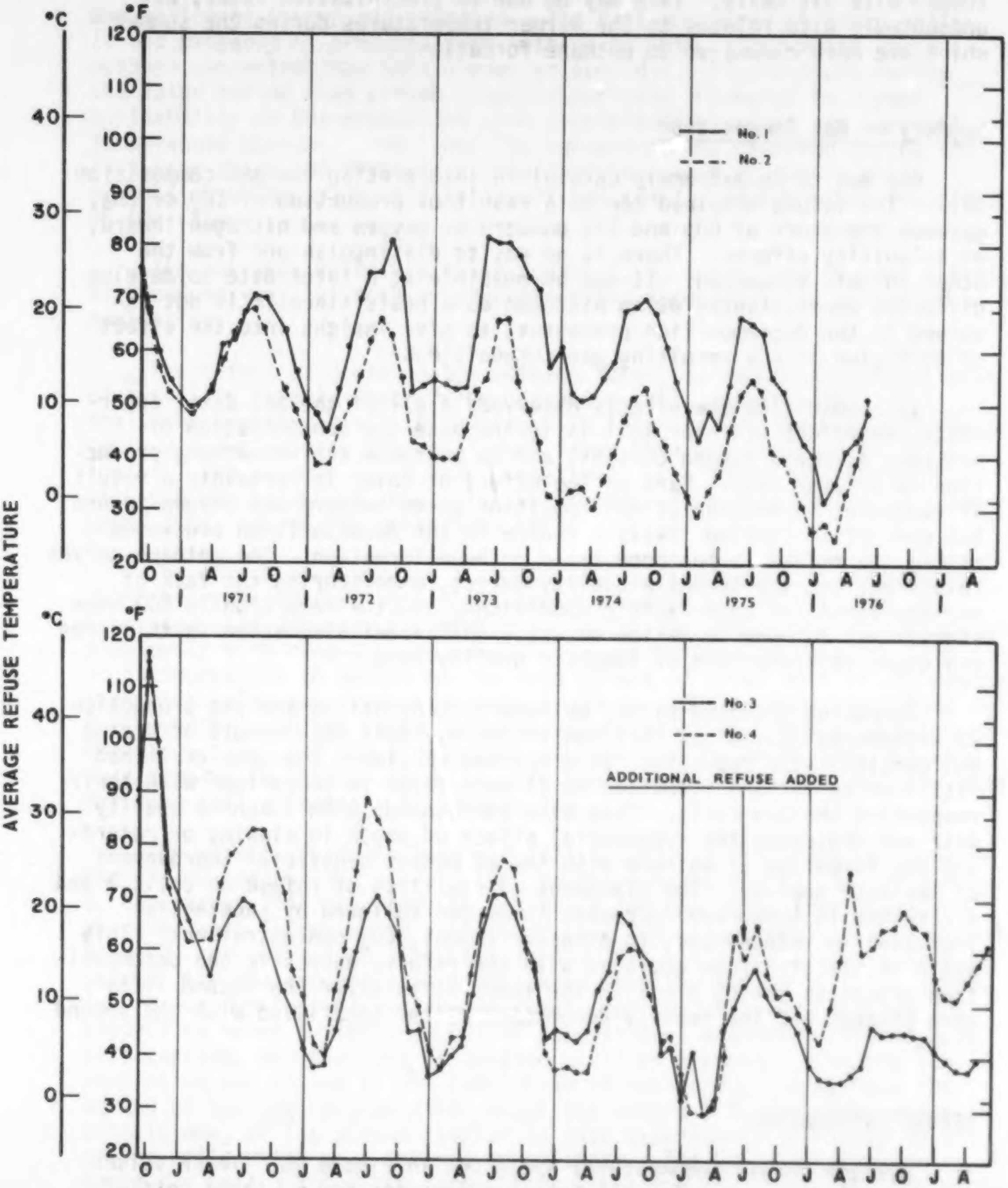

FIG. 18 AVERAGE REFUSE TEMPERATURE

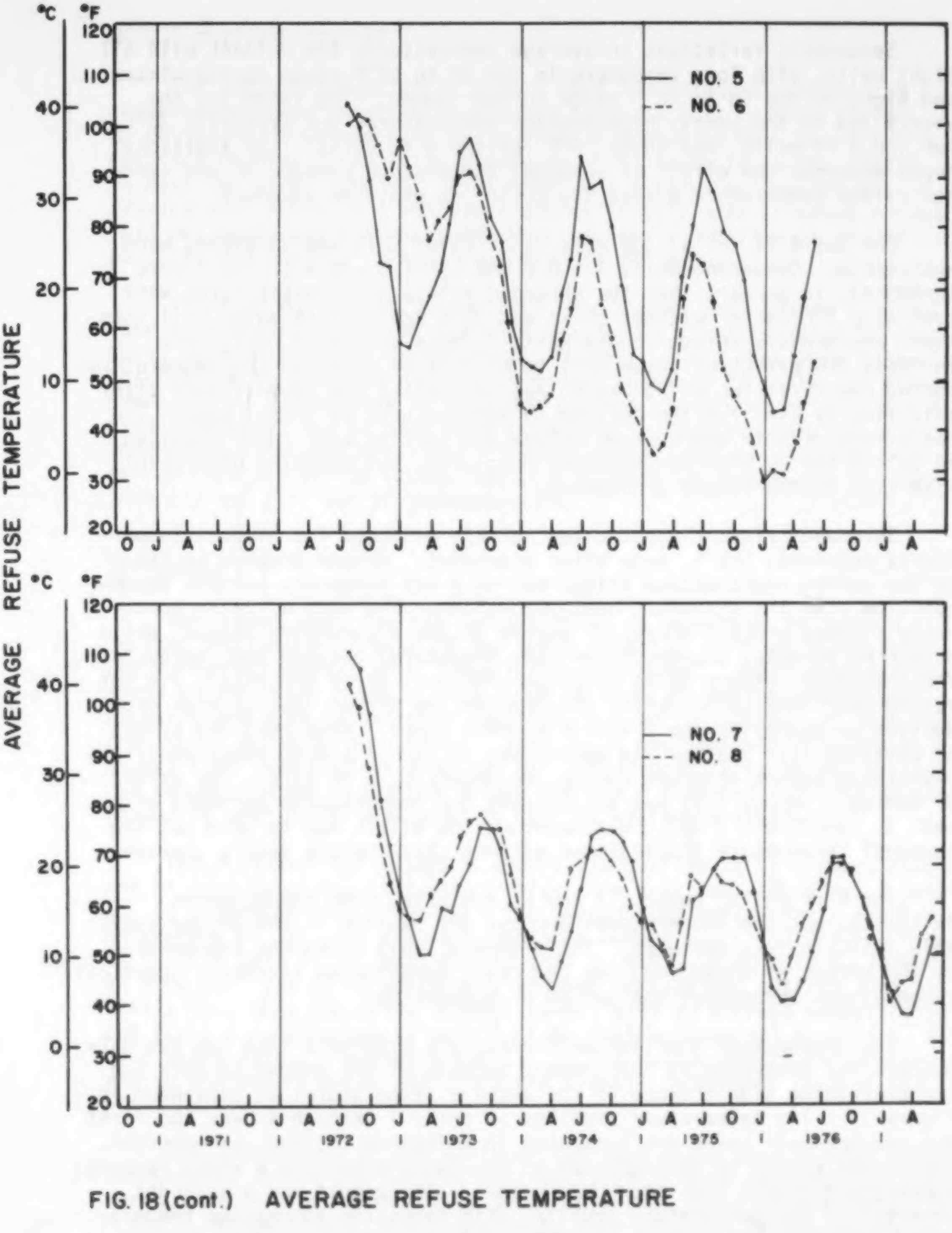

FIG. 18 (cont.) AVERAGE REFUSE TEMPERATURE

Seasonable variations in average temperatures are evident with all eight cells, with lows somewhere in the 30 to 50°F range during winter, and highs in the 60 to 90°F range in the summer. The range for the yearly low to the yearly high average temperatures was typically 30°F for the 4 ft cells, and 20 to 25°F for the 8 ft cells. The additional depth dampened the effect of seasonal temperature changes on the average refuse temperature within the cells, as would be expected.

For the 4 ft cells, the effects of cover soil and shredding were noticeable. Comparing cells 1 and 2 and cells 6 and 4 (2 and 4 were shredded), it appears that the shredded refuse cell temperatures were typically 5°F cooler without cover and 10°F cooler with cover soil than their unprocessed refuse counterparts. These same four cells also indicate the effect of cover soil to be that of lowering the temperatures during the first two or so years, but increasing the temperatures after this time by limiting the decline in temperatures as a cell ages. The net effect of both unprocessed refuse and lack of soil cover resulted in cell 6 having high temperatures initially, but dropping off rapidly with time as the refuse decomposed.

Shredded refuse without cover quickly produced the highest temperatures observed, 115°F, soon after placement. Oxygen trapped in the refuse during construction triggered rapid but temporary aerobic decomposition with the attendant heat production. The lack of cover apparently allowed greater access of oxygen to the decomposing refuse, while shredding promoted decomposition and, therefore, greater heat production. The insulating effect to be expected with soil cover apparently did not retard heat loss suffuciently to overcome the slower rate of heat production accompanying the presence of soil cover. Note that the effect of covering cell 3 after six months was to reduce almost immediately the peak temperatures attained during the summer by 5 to 15°F. The effect of adding a second lift was to increase the temperatures markedly of cell 4. With cell 3 which was covered, the effect was to even out the seasonal temperature fluctuations without changing the yearly averages.

The 8 ft cells, numbers 7 and 8, exhibited high temperatures initially, but the temperatures dropped off rapidly as the oxygen available initially was depleted. The effect of soil cover was compensated by the effect of shredding, and the cells experienced virtually identical temperatures throughout the period of monitoring.

The temperature profiles with depth are available from the raw data, but are not presented in this report because of the amount of data and the overriding significance of the average temperatures as presented in Figure 18. The temperature profiles of cells 1 through 4 over the first two and one-half years are presented in reference (1) and, as expected, the probes closer to the surfaces of the cells exhibited a wider seasonal temperature change than the lower probes. The result was a seasonal reversal of the temperature profile, with generally increasing temperatures with depth below the cell surfaces in the winter, and decreasing temperatures with depth in the summer.

REFUSE MOISTURE CONTENT

The temperature-moisture probes used for moisture content and temperature measurements were adapted from the soil testing field. Of particular importance in making this adapatation was use of a moisture content calibration procedure using leachate as the liquid to vary the probe reading. Also important during calibration was placing each probe in a container packed tightly with shredded refuse. This was necessary because probe readings are a function of liquid composition and physical pressure applied to the probe.

In order to improve reliability, the probes were placed in triplicate at each desired depth and were wrapped in asbestos prior to placement. Even with these improvements, however, the probes were increasingly insensitive to moisture changes at higher moisture contents and often proved to be insensitive to moisture content changes at levels less than field capacity, and so were used primarily to indicate only the initial movement of the moisture front to predict the onset of leachate production. This use of the probes for this purpose was discussed in reference (1) and will not be repeated here.

SETTLEMENT

Settlement data for the various cells is presented in Table 4. Surface settlement of each of the cells relative to fixed bench marks was monitored periodically since refuse placement. Settlement was measured as the mean change in elevation of five monitoring plates permanently emplaced at specific locations across the surface of each cell from their original elevations. Each plate was approximately one-half square foot (500 cm^2) in area and was placed originally approximately six inches (15 cm) below the refuse surface. Vertical sections of pipe welded to each plate were used to measure elevation changes.

There appears to be some seasonal fluctuation in settlement data, and in some cases the settlement values are negative. This was probably due to expansion from freezing. The unprocessed refuse cells settled an average of 38% more than the shredded refuse cells (cell 1 (unprocessed) vs 2, 34%; cell 6 (unprocessed) vs cell 4, 41%), using July 2, 1975 data as a basis. The cells which were covered immediately settled substantially less than the cells without cover, with an average reduction of 62% (cell 1 (uncovered) vs cell 6, 63%; cell 2 (covered) vs cell 4, 61%), also using July 2, 1975 as a basis. Cell 6, which contained unprocessed refuse and had no cover soil, had the highest settlement rate of all eight cells.

The bottom half of the walls of the deep cells were slanted toward the center, unlike the shallow cell walls which were vertical the entire depth. Cells 7 and 8 show less settlement than their counterparts, cells 4 and 1, respectively, due probably to some bridging of the refuse on these sloped sides, and also to the fact that these cells were still decomposing actively at the conclusion of the project.

Table 4. Cumulative Settlement (Centimeters)

	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
1970								
Oct. 19	0.0	0.0	0.0	0.0				
Oct. 26	0.0	0.6	0.9	1.2				
Nov. 4	-0.3	0.3	1.5	2.1				
Nov. 9	0.0	0.3	0.3	0.3				
Nov. 30	-0.3	0.3	0.6	0.0				
1971								
Feb. 11	0.3	0.6	0.9	0.6				
April 22	0.3	0.9	1.2	0.9				
June 23	0.6	0.6	1.5	1.5				
July 20	0.9	1.8	2.4	2.7				
Aug. 25	1.2	1.5	1.8	1.8				
Sept. 21	0.9	1.2	1.8	2.4				
Nov. 9	1.2	1.2	2.1	2.7				
Dec. 2	1.2	1.5	2.1	3.0				
1972								
March 23	1.5	1.2	0.3	0.0				
June 7	2.7	3.7	4.9	5.8				
Sept. 1	3.0	3.4	4.9	6.4	0.0	0.0	0.0	0.0
Dec. 4	3.4	3.0	4.6	7.0	0.3	1.8	0.3	0.0
1973								
March 6	3.4	3.0	5.2	7.3	0.3	3.7	0.0	0.3
April 3	4.0	3.7	5.2	7.9	0.3	*	1.2	0.3
May 31	3.7	3.7	5.5	7.6	0.3	4.9	0.0	-1.2
Sept. 7	4.3	3.4	5.8	8.5	0.6	7.6	2.1	0.6
1974								
Jan. 24	4.9	3.7	6.7	9.8	0.9	10.1	1.2	-0.6
March 6	5.2	4.0	7.6	10.1	0.9	11.0	1.8	0.0
June 28	5.5	4.3	7.9	10.7	1.5	13.1	3.0	1.2
Nov. 15	7.0	5.5	10.7	13.1	4.0	17.4	4.9	2.4
1975								
Feb. 28	6.7	4.6	10.7	13.4	4.0	19.5	4.0	0.9
May 14	7.6	5.8	10.7	14.3	4.9	19.2	5.5	3.0
July 2	8.2	6.1	12.2	15.5	6.4	21.9	6.4	3.7
1976								
Feb. 28	7.6	4.9	**	**	7.3	21.9	5.2	1.2
Sept. 26			2.7	2.4			7.3	3.0
1977								
March 25			4.6	3.7			7.9	3.4

*No data.
** Refuse added.

PHYSICAL APPEARANCE OF REFUSE AFTER DECOMPOSITION

Figure 19 is a photograph of the surface of cell 4, which consisted of shredded refuse and was not covered, just before the second lift was added. A spade had been used to dig a hole a few inches deep in order to see what was immediately beneath the surface. The refuse had been exposed to weathering and decomposition for five years at the time the picture was taken. Putrescible organic matter is decomposed to the extent it is unrecognizable, leaving items such as metals, glass, stones, and plastics clearly evident. Metals were heavily oxidized. Light gauge ferrous objects were rusty and brittle and often required some thought to identify.

The vegetation, which grew on its own without seeding or any other human action, is obvious in the picture. The vegetation appeared healthy, with extensive root development. Predominant types of vegetation changed on a given cell as it aged and also changed depending on whether a cell was covered or not. In general, vegetation was more dense, grew more vigorously, reached greater height, and grew sooner after cell construction when no cover was applied. Of the cells without cover, shredded refuse appeared to promote more vigorous growth of vegetation than unprocessed refuse.

Figure 19 provides graphic evidence of the change with time in surface characteristics of the cells without soil cover, giving rise to increasing amounts of runoff as these cells aged. It is clear why, after several years, the water budgets for the cells without cover approached those of the covered cells, as discussed earlier.

REFERENCES

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2. Standard Methods for the Examination of Water and Wastewater, Amer. Public Health Assoc., Amer. Water Works Assoc., and Water Polln. Control Fed., available at Amer. Public Health Assoc., 1015 18th St., N.W., Wash., D.C. 20036, 14th Ed. (1975).

3. Salvato, J.A., Wilkie, W.G., and B.E. Mead, "Sanitary Landfill-Leaching Prevention and Control," Journ. Water Polln. Control Fed., 43, 10, 2084-2100 (Oct., 1971).

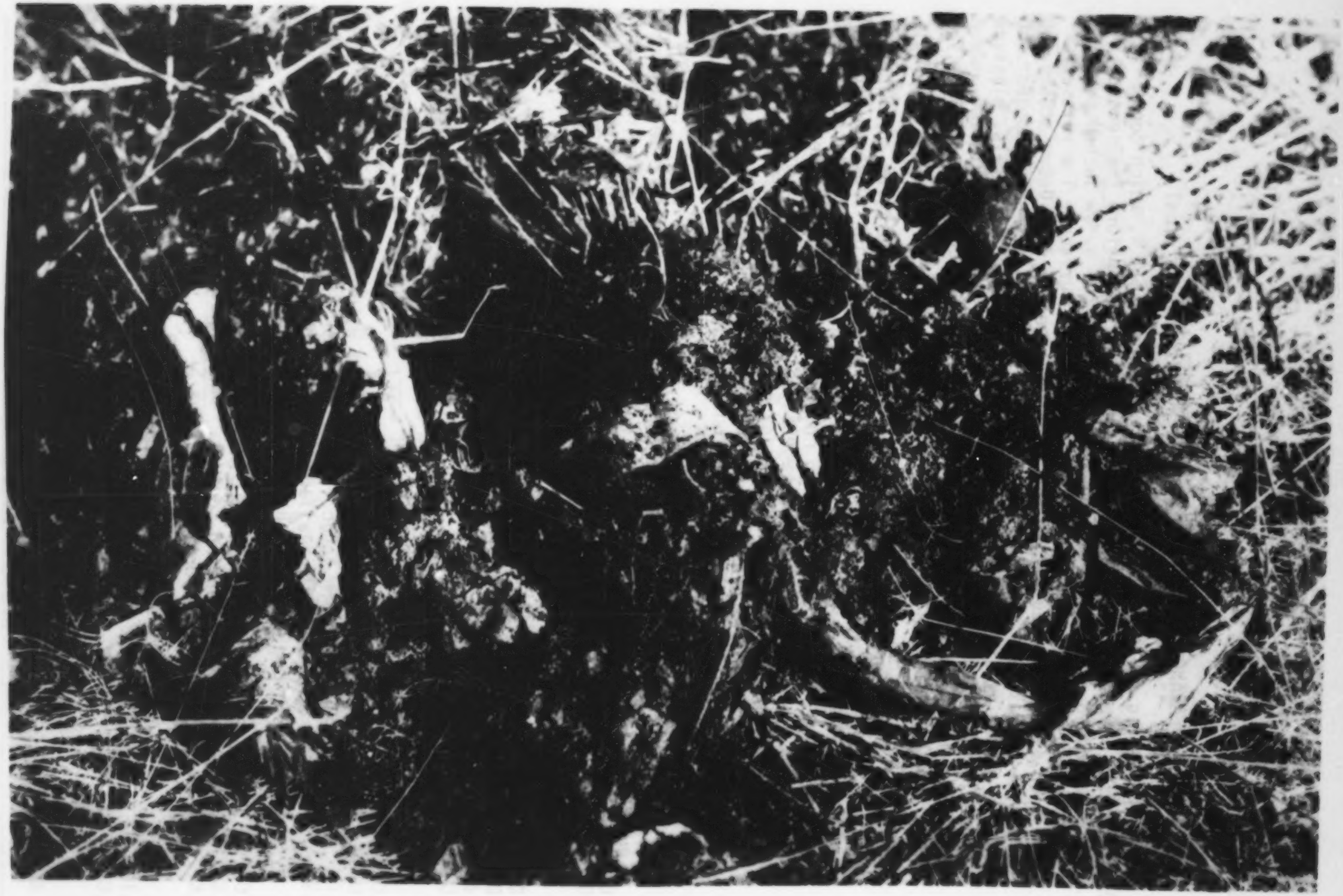

Figure 19. Refuse near the surface of cell 4 five years after cell construction.

APPENDIX

Table A-1. Precipitation Data and Chronology of Cell Construction

		Precip (in)	Precip (cm)	Accum Precip (cm)1-4	Accum Precip (cm)5-8	Chronology
	S	*4.81	*12.22	*12.22		Cells 1-4 constructed mid-September 1970
	O	2.65	6.73	18.95		
	N	1.06	2.69	21.64		
	D	2.12	5.38	27.02		
	Tot		27.02			
1971	J	1.48	3.76	30.78		
	F	2.59	6.58	37.36		
	M	1.52	3.86	41.22		
	A	2.42	6.15	47.37		
	M	0.98	2.49	49.86		
	J	2.27	5.77	55.63		
	J	1.65	4.19	59.82		
	A	3.96	10.06	69.88		
	S	1.87	4.75	74.63		
	O	1.30	3.30	77.93		
	N	3.48	8.84	86.77		
	D	3.64	9.25	96.02		
	Tot		69.00			
1972	J	0.40	1.02	97.04		
	F	0.42	1.07	98.11		
	M	2.23	5.66	103.77		
	A	2.02	5.13	108.90		
	M	2.83	7.19	116.09		
	J	1.65	4.19	120.28		
	J	3.49	8.86	129.14		
	A	**(5.50) 7.47	**(13.97) 18.97	148.11	**13.97	Cells 5-8 constructed mid-August 1972
	S	5.26	13.36	161.47	27.33	
	O	2.42	6.15	167.62	33.48	
	N	0.86	2.18	169.80	35.66	
	D	1.91	4.85	174.65	40.51	
	Tot		78.63			
1973	J	1.54	3.91	178.56	44.42	
	F	1.20	3.05	181.61	47.47	
	M	5.04	12.80	194.41	60.27	
	A	7.11	18.06	212.47	78.33	
	M	5.27	13.39	225.86	91.72	
	J	0.81	2.06	227.92	93.78	
	J	2.68	6.81	234.73	100.59	
	A	2.53	6.43	241.16	107.02	
	S	3.59	9.12	250.28	116.14	
	O	2.30	5.84	256.12	121.98	
	N	1.48	3.76	259.88	125.74	
	D	1.98	5.03	264.91	130.77	
	Tot		90.26			

Table A-1. Precipitation Data and Chronology of Cell Construction (Continued)

		Precip (in)	Precip (cm)	Accum Precip (cm) 1-4	Accum Precip (cm) 5-8	Chronology
1974	J	2.45	6.22	271.13	136.99	
	F	1.17	2.97	274.10	139.96	
	M	3.43	8.71	282.81	148.67	
	A	4.24	10.77	293.58	159.44	
	M	5.77	14.66	308.24	174.10	
	J	3.86	9.80	318.04	183.90	
	J	2.69	6.83	324.87	190.73	
	A	4.60	11.68	336.55	202.41	
	S	1.08	2.74	339.29	205.15	
	O	3.18	8.08	347.37	213.23	
	N	1.79	4.55	351.92	217.78	
	D	1.80	4.57	356.49	222.35	
	Tot		91.58			
1975	J	0.98	2.49	358.98	224.84	
	F	1.54	3.91	362.89	228.75	
	M	3.09	7.85	370.74	236.60	
	A	4.19	10.64	381.38	247.24	
	M	4.57	11.61	392.99	258.85	
	J	4.30	10.92	403.91	269.77	
	J	6.05	15.37	419.28	285.14	New lift of refuse to cells 3 & 4
	A	5.25	13.34	432.62	298.48	
	S	0.84	2.13	434.75	300.61	
	O	0.64	1.63	436.38	302.24	
	N	2.79	7.09	443.47	309.33	
	D	0.29	0.74	444.21	310.07	
	Tot		87.72			
1976	J	0.56	1.42	445.63	311.49	
	F	1.72	4.37	450.00	315.86	
	M	4.75	12.06	462.06	327.92	
	A	4.80	12.19	474.25	340.11	
	M	1.95	4.95	479.20	345.06	Cells 1&2 terminated
	J	1.38	3.51	482.71	348.57	Cells 5&6 terminated
	J	1.46	3.71	486.42	352.28	
	A	1.99	5.05	491.47	357.33	
	S	0.50	1.27	492.74	358.60	
	O	1.49	3.78	496.52	362.38	
	N	0.11	0.28	496.80	362.66	
	D	0.37	0.94	497.74	363.60	
	Tot		53.53		–	
1977	J	0.53	1.35	499.09	364.95	
	F	1.44	3.66	502.75	368.61	
	M	3.03	7.70	510.45	376.31	
	A	2.59	6.58	517.03	382.89	
	M	2.52	6.40	523.43	389.29	
	J	2.63	6.68	530.11	395.97	
	Tot		32.37			

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*September rainfall after cells 1-4 constructed

**August rainfall after cells 5-8 constructed

Table A-2. Runoff Volume (liters/day average since previous sampling)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
	S	0.0	0.0	0.0	0.0				
	O	24.7	19.5	0.0	0.0				
	N	7.9	2.0	0.0	0.0				
	D	0.0	0.0	0.0	0.0				
	Ave	8.2	5.4	0.0	0.0				
1971	J	0.0	0.0	0.0	0.0				
	F	121.3	118.9	0.0	0.0				
	M	66.5	64.8	1.1	0.0				
	A	13.9	5.0	2.4	0.0				
	M	7.3	2.5	0.5	0.0				
	J	122.5	126.8	70.5	0.0				
	J	0.0	0.0	0.0	0.0				
	A	162.2	162.9	157.5	0.0				
	S	27.5	26.9	35.2	0.0				
	O	1.4	1.2	1.1	0.0				
	N	0.0	0.0	0.0	0.0				
	D	77.2	78.6	78.8	10.9				
	Ave	50.0	49.0	28.9	0.9				
1972	J	0.0	0.0	0.0	0.0				
	F	82.2	80.6	81.0	20.3				
	M	0.0	0.0	0.0	0.0				
	A	26.9	51.2	34.1	4.5				
	M	7.2	9.7	6.9	1.0				
	J	9.7	9.5	10.4	1.8				
	J	0.0	0.0	10.5	3.8				
	A	47.5	67.4	76.1	30.3	0.0	0.0	0.0	0.0
	S	26.2	92.5	90.2	52.4	24.6	27.1	21.3	79.3
	O	0.0	1.1	0.7	0.0	0.0	0.0	0.0	0.0
	N	4.2	0.0	0.0	0.0	1.1	0.7	2.6	14.7
	D	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Ave	17.0	26.0	25.8	9.5	5.1	5.6	4.8	18.8
1973	J	135.2	106.7	143.0	26.8	15.6	0.0	18.2	69.4
	F	16.7	28.5	33.4	0.0	1.5	20.5	24.0	0.0
	+ M	59.5	105.9	64.6	60.6	68.8	26.5	92.9	128.2 +
	+ A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0 +
	+ M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0 +
	J	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.6
	J	13.9	19.8	10.9	6.7	12.3	15.3	68.1	91.0
	A	22.5	16.4	13.1	9.4	9.3	12.2	6.4	45.6
	S	31.4	37.2	35.1	24.1	10.3	19.4	12.5	48.4
	O	3.8	5.5	6.4	5.5	16.4	26.3	11.4	89.6
	N	15.6	13.0	13.8	22.3	0.0	0.0	0.0	0.0
	D	0.0	0.0	0.0	0.0	18.6	37.2	10.1	29.3
	Ave. incl+	24.9	27.8	26.7	13.0	12.7	13.1	20.3	42.7
	Ave. excl+	26.6	25.2	28.4	10.5	9.3	14.5	16.7	42.7

Table A-2. Runoff Volume (liters/day average since previous sampling) (Continued)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
1974	J	124.5	163.9	167.0	28.8	5.3	10.2	14.5	142.7
	F	58.5	47.7	89.4	14.7	8.8	15.8	4.3	4.3
	M	27.6	22.6	39.7	20.4	11.6	29.5	11.1	102.2
	A	16.0	10.8	17.7	x13.6	x20.2	x31.7	23.7	124.6
	M	47.7	69.4	45.8	x25.0	x29.8	x26.2	37.5	126.9
	J	24.5	30.7	21.3	13.8	19.5	9.5	22.3	66.2
	J	9.5	7.1	6.7	10.3	3.5	4.3	5.7	20.4
	A	11.0	10.6	10.2	9.3	12.3	15.7	9.8	45.3
	S	0.0	0.0	0.0	0.0	5.5	8.3	1.2	5.2
	O	12.3	13.7	15.1	13.7	12.2	13.8	7.1	18.0
	N	15.8	18.9	13.6	10.2	5.9	8.4	5.9	15.0
	D	0.0	0.0	0.0	0.0	13.7	18.0	15.5	60.1
	Ave	29.0	33.0	35.5	13.3	12.4	16.0	13.2	60.9
1975	J	6.3	18.6	6.6	3.5	5.3	10.1	3.0	75.2
	F	0.0	0.0	0.0	b *	1.1	1.1	1.4	12.2
	M	70.6	56.5	68.4	b *	7.0	11.2	5.8	b *
	A	15.6	27.9	24.8	a17.0	23.1	22.3	16.4	a133.2
	M	9.5	10.2	10.7	8.2	8.5	6.9	7.3	27.8
	J	23.9	26.9	21.7	27.7	14.9	19.3	14.1	32.3
	J	17.6	36.8	**18.6	**18.9	20.3	26.7	20.3	63.2
	A	14.6	11.1	78.3	11.1	23.3	17.2	10.3	25.7
	S	6.5	7.3	18.7	7.4	9.2	7.6	3.1	8.3
	O	13.5	11.6	53.0	14.5	11.4	12.2	8.2	13.5
	N	24.3	14.7	109.2	27.7	17.0	23.4	12.4	22.6
	D	8.2	1.1	8.7	12.7	22.7	26.0	21.4	28.7
	Ave	17.6	18.6	34.9	14.9	13.6	15.3	10.3	40.2
1976	J	1.8	1.8	1.8	1.8	8.7	7.6	9.1	8.7
	F	31.9	x 11.4	71.2	38.0	3.5	3.5	3.5	40.3
	M	38.3	10.8	61.6	42.6	40.6	37.9	29.1	66.9
	A	20.7	15.0	109.0	17.1	17.9	19.0	15.6	32.1
	M	7.0	3.8	68.0	7.2	3.0	7.6	5.0	7.0
	J			2.7	1.2	4.3	8.7	3.1	6.3
	J			51.0	6.3			3.0	20.6
	A			99.6	22.9			12.2	62.5
	S			3.2	3.2			2.4	6.1
	O			14.1	12.7			11.8	14.9
	N			0.0	0.0			0.0	0.0
	D			0.0	0.0			0.0	0.0
	Ave	19.9	8.6	40.2	12.8	13.0	14.0	7.9	22.1
1977	J			0.0	0.0			0.0	0.0
	F			59.7	13.2		-	8.0	81.3
	M			28.1	19.9			15.6	23.0
	A			11.3	5.6			6.7	10.9
	M			38.3	12.3			13.0	23.8
	J			26.6	7.0			8.5	14.7
	Ave			27.3	9.7			8.6	25.6

* No data available

** New lift added

x high value, gutter broken, runoff probably in leachate system

a total since previous successful sampling

b pump breakdown

Table A-3. Leachate Volume (liters/day average since previous sampling)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
	S	127.9	128.4	28.1	30.0				
	O	9.6	10.0	4.6	4.9				
	N	3.8	6.8	0.0	11.9				
	D	1.4	0.0	16.9	8.3				
	Ave	35.7	36.3	12.4	13.8				
1971	J	28.0	30.6	38.1	26.4				
	F	84.3	106.4	114.6	93.4				
	M	81.3	133.6	190.7	94.3				
	A	50.6	29.6	74.0	79.9				
	M	13.1	12.9	31.7	48.5				
	J	30.4	15.1	79.0	59.9				
	J	9.8	12.1	29.6	61.3				
	A	33.8	53.4	66.7	85.2				
	S	12.3	17.9	38.4	35.2				
	O	61.9	70.7	58.9	98.0				
	N	62.6	88.6	60.8	114.5				
	D	23.1	37.7	30.1	51.9				
	Ave	40.9	50.7	67.7	70.7				
1972	J	22.2	30.5	36.0	37.9				
	F	152.6	38.1	31.8	40.4				
	M	112.6	135.7	94.5	119.1				
	A	142.1	155.1	133.5	159.0				
	M	62.2	75.4	75.8	125.3				
	J	27.6	29.1	42.7	82.9				
	J	25.5	23.7	56.4	54.0				
	A	134.3	154.5	161.2	167.9	0.0	0.0	0.0	0.0
	S	178.1	159.0	153.7	170.3	0.0	11.6	0.0	0.0
	O	136.0	138.1	104.6	109.8	30.3	0.0	28.7	1.9
	N	49.1	84.5	55.1	70.9	44.7	38.8	1.6	1.0
	D	77.9	103.9	100.1	95.9	8.5	8.5	1.2	0.0
	Ave	93.4	94.0	87.1	102.8	16.7	11.8	6.3	0.6
1973	J	268.5	148.1	130.1	129.0	65.6	57.4	35.6	11.1
	F	126.0	126.0	85.1	126.2	92.6	65.8	61.1	17.5
	M	473.5	251.2	147.3	147.0	134.5	77.6	192.5	82.7
	+ A	676.8	279.4	226.9	231.9	161.6	63.3	439.2	264.7 +
	M	335.3	335.3	214.6	168.0	190.1	91.7	301.4	280.0
	J	92.4	128.9	97.0	94.3	148.0	74.9	131.8	87.8
	J	83.6	104.1	78.4	57.8	112.3	76.1	11.2	31.2
	A	79.6	65.5	64.2	51.3	48.5	38.0	19.2	19.7
	S	65.0	37.9	69.5	83.3	21.1	37.7	19.1	9.0
	O	52.0	55.2	39.3	48.7	74.6	48.0	52.0	17.6
	N	50.9	99.0	60.9	73.3	39.7	27.4	0.0	0.0
	D	48.7	121.8	56.5	58.0	89.4	36.7	70.0	15.4
	Ave. incl+	196.0	146.0	105.8	105.7	98.2	57.9	111.1	69.7
	Ave. excl+	96.3	98.5	75.7	80.2	76.9	51.3	44.4	23.3

Table A-3. Leachate Volume (liters/day average since previous sampling (Continued)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
1974	J	101.1	143.2	96.0	100.2	70.7	23.0	84.8	43.4
	F	124.9	133.1	83.0	107.4	113.2	43.3	157.9	64.9
	M	270.8	193.2	140.1	187.9	132.8	40.2	114.2	76.4
	A	120.3	132.1	64.8	x 71.4	x 89.0	x 70.0	221.6	199.7
	M	274.5	168.5	110.6	x121.0	x229.3	x 86.1	250.6	253.5
	J	128.7	159.3	84.6	82.1	174.7	74.7	240.9	122.6
	J	19.5	94.1	38.1	26.0	59.2	35.0	59.3	37.1
	A	21.5	61.5	33.4	26.2	39.7	32.0	34.0	37.3
	S	9.9	18.4	12.7	3.6	8.8	7.9	6.5	11.7
	O	14.0	30.1	14.3	9.5	31.0	24.7	35.4	44.1
	N	39.0	96.1	44.1	20.9	27.4	10.1	30.9	52.1
	D	18.8	45.7	108.1	27.7	43.8	11.6	51.9	62.1
	Ave	95.2	106.3	69.2	65.3	85.0	38.2	107.3	83.7
1975	J	8.6	24.6	16.0	0.0	16.1	11.4	52.6	51.2
	F	27.3	27.3	27.3	b *	7.1	14.2	9.1	0.0
	M	120.8	157.4	109.8	b *	13.3	8.5	28.3	b *
	A	192.5	135.7	123.1	a 48.1	49.7	8.1	195.6	a 130.5
	M	48.7	70.1	17.4	12.0	60.6	30.3	105.5	123.7
	J	25.6	107.3	58.8	53.0	82.9	23.7	41.4	99.6
	J	65.7	118.8	**62.9	**146.9	7.1	8.0	153.2	159.1
	A	18.5	69.9	40.2	29.3	20.5	4.2	17.7	b *
	S	11.6	15.4	17.2	15.4	12.8	16.6	74.5	a 34.3
	O	8.3	10.8	14.0	2.5	6.2	4.1	32.9	28.3
	N	42.0	40.4	41.4	21.7	5.7	9.9	28.8	20.5
	D	20.5	48.8	0.0	0.0	11.9	9.7	48.8	6.1
	Ave	49.2	68.9	44.0	32.9	24.5	12.4	65.7	65.3
1976	J	7.0	15.4	0.0	10.0	7.6	5.2	32.6	33.1
	F	86.4	161.0	75.6	22.6	0.4	0.4	28.5	22.7
	M	113.7	145.7	88.0	80.6	31.4	20.8	145.2	240.9
	A	128.3	113.2	73.4	53.7	48.0	16.3	184.8	251.8
	M	19.3	110.6	68.0	155.6	21.8	12.0	173.4	184.6
	J			16.4	42.0	11.6	11.1	87.1	60.7
	J			52.1	51.3			94.1	49.6
	A			32.2	33.6			101.7	38.5
	S			14.5	10.9			61.3	22.7
	O			5.8	8.8			51.2	16.1
	N			3.2	2.3			33.9	12.0
	D			0.0	0.3			23.8	11.1
	Ave	70.9	109.2	35.8	39.3	20.1	11.0	84.8	78.6
1977	J			0.0	0.0			18.8	6.9
	F			19.5	2.9			71.2	60.1
	M			27.0	27.0			163.5	155.2
	A			34.4	16.5			161.1	128.0
	M			26.2	66.2			131.9	63.9
	J			29.9	65.0			132.0	49.3
	Ave			22.8	29.6			113.1	77.2

* No data available

** New lift added

x high value, gutter broken, runoff probably in leachate system

a total since previous successful sampling

b pump breakdown

Table A-4. Leachate COD Concentration (mg/ℓ)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
	S	10200	13700	16850	10350				
	O	7799	17077	20524	10853				
	N	9266	25504	*	912				
	D	9975	28158	10534	8618				
	Ave	9310	21110	15969	7683				
1971	J	7270	21272	9526	8668				
	F	8025	24717	34454	29211				
	M	13625	23500	32500	25000				
	A	11438	22078	31654	27830				
	M	8100	26400	30200	22200				
	J	6213	23980	28013	16132				
	J	6105	20979	14541	3996				
	A	4814	11954	2326	2122				
	S	5191	6757	1401	1607				
	O	4668	4309	1436	1436				
	N	3412	5052	848	1536				
	D	9390	27352	8188	2916				
	Ave	7354	18196	16257	11888				
1972	J	9114	22694	2583	1255				
	F	1848	1656	558	578				
	M	4493	6513	2130	3715				
	A	8330	16856	12544	8036				
	M	9964	20102	6817	3671				
	J	4120	18300	1520	700				
	J	2914	8440	747	678				
	A	5230	12005	1642	803	71	1927	*	*
	S	6836	8882	1192	772	*	20553	57876	13013
	O	7774	11730	1815	641	20253	*	51380	7630
	N	1901	7269	704	423	30830	28480	68886	14240
	D	2410	4346	3420	906	7919	9048	72558	*
	Ave	5411	11566	2973	1848	14768	15002	62675	11628
1973	J	3449	3391	1607	735	26730	6732	39501	11395
	F	1563	2809	1321	549	25175	4085	46455	13300
	M	14000	25037	5296	1137	22748	7877	47376	20821
	A	10773	21635	3988	970	19208	4757	52186	32978
	M	11388	30711	3124	570	13749	1987	60316	27497
	J	6670	27520	848	406	8104	1937	70288	33779
	J	3731	18277	836	396	3704	1761	47716	26744
	A	1708	4664	581	345	1917	730	39603	23360
	S	1305	1794	471	437	1059	754	39132	21091
	O	437	1180	453	407	2182	806	39018	23132
	N	2775	6837	897	348	1210	531	*	*
	D	641	4608	432	299	2365	570	38528	35840
	Ave	4870	12372	1654	550	10679	2711	47284	24540

Table A-4. Leachate COD Concentration (mg/ℓ) (Continued)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
1974	J	473	1458	678	239	840	476	34216	13254
	F	1226	2355	1136	316	2557	560	35720	25568
	M	3399	792	2213	378	2733	552	27418	27149
	A	1888	7973	1667	364	2167	626	33263	38478
	M	2316	4800	1036	293	2812	976	27256	28904
	J	730	2197	462	286	961	480	26058	32429
	J	244	518	362	162	482	378	23243	28799
	A	293	644	307	218	467	443	24653	34354
	S	270	544	298	149	324	321	26014	29220
	O	328	540	285	181	319	382	26931	30778
	N	824	807	317	136	269	378	25085	28917
	D	310	507	309	155	460	379	25459	33456
	Ave	1025	1928	756	240	1199	496	27943	29276
1975	J	251	361	290	147	294	381	27330	30063
	F	171	324	235	*	234	333	29201	*
	M	1065	8040	421	354	231	561	29710	27425
	A	1014	6179	2001	321	1165	645	26776	26776
	M	310	6092	1207	258	258	560	25816	29543
	J	296	515	270	236	278	543	22424	25732
	J	302	429	** 510	** 445	339	460	24192	28728
	A	242	401	483	376	301	308	25339	28632
	S	233	385	486	466	295	347	19067	25596
	O	239	384	329	440	196	442	23629	28932
	N	361	562	328	431	161	315	21282	26759
	D	238	515	*	*	201	387	21844	25316
	Ave	394	2016	596	347	329	440	24718	27591
1976	J	127	311	*	159	160	322	21657	30374
	F	173	463	264	1586	277	597	20605	14793
	M	979	2466	837	13747	245	291	20313	26888
	A	826	2000	494	9499	249	418	24109	27117
	M	323	2512	351	7142	612	394	22057	28919
	J			257	2241	241	503	20146	26340
	J			314	1391			18983	28639
	A			306	1430			12863	30688
	S			157	2051			20249	28476
	O			357	2268			23181	36364
	N			260	2265			19010	36234
	D			*	1811			1993	37560
	Ave	486	1550	360	3799	297	421	18764	29366
1977	J			*	1707			2300	34260
	F			296	1625			10607	36287
	M			252	2500			10840	25896
	A			362	10728			10243	30764
	M			280	2427			8416	27238
	J			343	2981			8202	23847
	Ave			307	3661			8435	29715

*No data available

**New lift added

Table A-5. Leachate Specific Conductance (@ 25°C, Micromhos/cm)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
	S	5650	7600	9630	6700				
	O	4080	9700	10100	7050				
	N	4470	12400	*	2320				
	D	4400	10600	6320	6000				
	Ave	4650	10075	8683	5518				
1971	J	5050	11150	10250	9655				
	F	4800	11200	15400	14400				
	M	7150	9350	13500	12400				
	A	6600	10700	15650	15000				
	M	5600	12150	15900	14000				
	J	5570	11900	15900	13050				
	J	5050	11650	11680	11650				
	A	3280	5690	6250	8480				
	S	3690	5440	7000	10000				
	O	3210	4780	7020	9600				
	N	3340	4900	4920	9400				
	D	6280	12100	9670	9180				
	Ave	4968	9251	11095	11401				
1972	J	6320	11400	7760	9280				
	F	2090	1975	4960	5550				
	M	3300	4900	6000	6000				
	A	6687	10972	11211	8830				
	M	7650	13025	9384	7120				
	J	6717	11868	9394	6640				
	J	5200	6310	5780	5730				
	A	6360	8200	5920	5100	465	3510	*	*
	S	6480	7500	4990	4770	*	11480	18100	5180
	O	7900	9200	4890	3480	16900	*	22800	4600
	N	6880	8520	5700	3290	18300	14080	22000	6370
	D	4390	5600	5130	3380	17750	12040	22600	*
	Ave	5831	8289	6760	5764	13354	10278	21375	5383
1973	J	3730	4170	4440	2860	17800	10285	15450	5480
	F	4850	4380	4480	3160	15800	11300	17100	6300
	M	8130	12070	5990	2500	12250	10900	16100	8980
	A	6850	10140	4860	2050	11980	7840	18200	13830
	M	6740	13600	5220	2700	10020	6900	18600	12350
	J	6470	14050	6400	3220	11150	8870	23800	15400
	J	5930	12450	6300	3200	9700	7650	16900	12470
	A	3800	9300	4920	2730	10250	7600	17500	11600
	S	3080	4300	2580	3520	8530	6300	15200	9000
	O	4080	6400	3660	2570	8380	7280	14800	9440
	N	4000	7980	3200	2510	6730	5700	*	*
	D	3600	7280	3150	2420	7500	4790	14800	12800
	Ave	5105	8843	4600	2787	10841	7951	17132	10695

Table A-5. Leachate Specific Conductance (@ 25°C, micromhos/cm)(Continued)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
1974	J	1850	3630	2120	2080	6800	4300	13030	5720
	F	2180	2950	2180	1750	6620	3950	13000	10200
	M	3400	5520	2630	1490	6000	3360	10450	10350
	A	3520	6550	3100	1920	5330	3100	12000	13200
	M	4290	6100	3250	1900	5200	2830	12100	12700
	J	3600	5150	3040	2000	4950	3300	10600	12350
	J	3600	5080	3350	1850	5400	3550	10075	12050
	A	2680	4580	2600	2180	4600	3140	10150	13900
	S	3600	4580	3000	2750	4140	3000	10225	11400
	O	3340	3670	3500	3150	4080	3150	10400	11700
	N	3050	3780	2370	2780	4290	3000	9300	11190
	D	3100	3330	2320	2200	3040	2380	8500	12200
	Ave	3184	4577	2788	2171	5038	3255	10819	11413
1975	J	2400	2370	2120	2250	2680	2400	9450	11250
	F	2800	2470	2775	*	3300	2850	9400	*
	M	1800	3130	2400	2560	3690	2600	10150	10750
	A	2580	4450	3030	2880	3480	2620	10700	12200
	M	2700	5000	2720	1600	2120	2450	9750	12000
	J	2430	3010	2310	1780	2390	2290	8430	10750
	J	2640	2700	** 2480	** 1750	4640	4180	9610	12420
	A	2410	3060	2540	1800	4620	3890	8050	16000
	S	2510	2780	2410	1690	2300	2250	7900	14200
	O	2610	2910	2490	1840	3330	2290	8190	11210
	N	2520	2640	2400	2130	2890	3280	8300	11900
	D	2563	3399	*	*	3060	2880	8500	11780
	Ave	2497	3160	2516	2028	3208	2832	9036	12224
1976	J	3135	3135	*	2464	2849	2761	8910	13915
	F	2690	2680	2720	5620	2968	3125	8758	7885
	M	2790	2700	3290	12000	1950	2520	7800	11750
	A	2400	2690	3480	12400	2190	1730	9550	12200
	M	2430	2900	3180	14980	1890	1420	7810	10380
	J			3440	12240	1910	1640	7385	11915
	J			2570	11200			6680	11200
	A			1900	9700			6300	13200
	S			2100	14200			4100	12300
	O			2100	14200			4100	12300
	N			2700	9400			3700	13500
	D			*	9800			3500	13400
	Ave	2689	2821	2748	10684	2293	2199	6549	11995
1977	J			*	9000			3500	13400
	F			3100	7100			3900	7900
	M			3000	6100			3400	7100
	A			3000	11400			3700	12500
	M			2200	9200			2500	8500
	J			2620	12500			3700	10200
	Ave			2784	9217			3450	8300

*No data available

**New lift added

Table A-6. Leachate pH

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
	S	6.18	6.18	6.53	6.08				
	O	5.63	5.55	5.70	5.68				
	N	*	5.45	*	7.23				
	D	6.30	5.40	6.20	6.50				
	Ave	6.04	5.64	6.14	6.37				
1971	J	6.48	5.70	6.98	7.05				
	F	6.00	5.45	6.35	6.25				
	M	5.85	5.70	6.00	5.95				
	A	5.95	5.65	6.00	5.95				
	M	6.20	5.40	5.95	6.35				
	J	6.35	5.40	6.00	6.70				
	J	6.08	5.33	6.35	7.23				
	A	6.03	5.38	6.92	7.22				
	S	6.00	6.75	7.22	7.35				
	O	6.10	6.75	7.15	7.25				
	N	6.70	6.85	7.15	7.35				
	D	6.28	5.45	6.95	7.30				
	Ave	6.17	5.82	6.58	6.83				
1972	J	6.25	5.45	7.10	7.25				
	F	6.45	6.30	6.95	7.15				
	M	6.15	6.05	6.75	6.90				
	A	6.31	5.69	6.50	6.58				
	M	6.41	5.65	6.84	6.96				
	J	6.64	5.77	6.99	6.99				
	J	6.58	6.23	6.81	6.90				
	A	6.63	6.06	6.82	6.85	6.15	5.46	*	*
	S	6.40	6.38	6.73	6.79	*	5.72	5.81	5.54
	O	6.52	6.50	6.79	6.73	6.88	*	5.81	5.61
	N	7.00	6.88	6.91	6.79	6.22	5.59	5.83	5.50
	D	6.80	6.48	6.79	6.73	7.50	7.29	5.72	*
	Ave	6.51	6.12	6.83	6.88	6.69	6.02	5.79	5.55
1973	J	6.48	6.51	6.76	6.69	6.29	7.18	5.48	5.40
	F	6.87	6.59	6.85	6.77	6.23	7.40	5.39	5.61
	M	5.91	5.91	6.68	6.72	5.99	7.09	5.71	5.58
	A	5.81	5.84	6.50	6.66	6.01	7.01	5.73	5.68
	M	6.01	5.80	6.76	6.67	6.26	6.99	5.79	5.45
	J	6.41	5.90	6.91	6.77	7.12	7.24	5.93	5.45
	J	6.62	6.27	6.93	6.77	7.17	7.18	5.63	5.31
	A	6.99	7.08	7.00	6.91	7.37	7.38	5.51	5.40
	S	6.49	6.72	6.69	6.69	7.60	7.20	5.33	5.49
	O	6.73	6.89	6.72	6.61	6.93	6.99	5.10	5.22
	N	6.71	6.62	6.71	6.70	7.98	7.41	*	*
	D	6.90	6.89	6.70	6.68	6.91	7.15	5.10	5.30
	Ave	6.49	6.42	6.77	6.71	6.82	7.18	5.52	5.44

Table A-6. Leachate pH (Continued)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
1974	J	6.58	6.60	6.53	6.64	7.05	7.27	5.03	5.21
	F	6.39	6.32	6.42	6.60	6.91	7.30	5.03	5.25
	M	6.46	6.24	6.50	6.60	6.79	6.98	5.07	5.30
	A	6.60	6.50	6.68	6.50	6.72	6.91	5.11	5.27
	M	6.62	6.60	6.65	6.57	6.63	6.95	5.10	5.37
	J	6.60	6.70	6.59	6.64	6.83	6.80	5.09	5.50
	J	6.73	6.87	6.71	6.69	6.89	6.90	5.03	5.38
	A	6.72	6.84	6.79	6.66	6.90	6.99	5.12	5.41
	S	7.15	7.11	7.11	7.10	6.71	6.94	5.14	5.43
	O	6.70	6.88	6.65	6.61	6.58	6.88	5.20	5.43
	N	6.84	6.82	6.71	6.67	6.60	7.19	5.13	5.42
	D	6.80	6.73	6.78	6.85	7.08	7.14	5.08	5.30
	Ave	6.68	6.68	6.68	6.68	6.81	7.02	5.09	5.36
1975	J	6.62	6.55	6.61	6.85	7.11	7.37	5.09	5.29
	F	6.58	6.58	6.60	*	6.85	7.23	5.09	*
	M	6.66	6.25	6.68	6.60	6.58	7.30	5.11	5.30
	A	6.73	6.31	6.51	6.82	6.91	7.32	5.13	5.35
	M	6.69	6.43	6.58	6.74	6.81	7.18	5.05	5.38
	J	6.67	6.72	6.71	6.71	6.88	7.23	5.09	5.40
	J	6.62	6.60	** 6.65	** 6.71	6.65	7.20	5.15	5.45
	A	6.71	6.82	6.72	6.66	6.72	7.24	5.15	5.13
	S	6.77	6.71	6.79	6.72	7.02	7.40	5.20	5.41
	O	6.71	6.70	6.71	6.62	6.70	7.79	5.12	5.21
	N	6.50	6.53	6.72	7.00	6.90	7.03	5.25	5.41
	D	7.33	7.05	*	*	6.92	7.51	5.17	5.42
	Ave	6.72	6.60	6.66	6.74	6.84	7.32	5.13	5.34
1976	J	6.79	6.82	*	7.09	7.82	7.92	5.25	5.32
	F	6.79	7.11	7.00	7.21	7.42	7.94	5.30	5.49
	M	6.90	6.53	7.04	6.72	7.50	7.69	5.38	5.43
	A	6.72	6.60	6.99	7.00	7.41	7.42	5.25	5.38
	M	7.11	6.83	7.29	7.51	7.52	7.63	5.22	5.45
	J			6.70	7.39	7.11	7.38	5.26	5.46
	J			6.75	7.48			5.29	5.51
	A			6.91	7.71			5.45	5.60
	S			7.12	7.80			7.39	7.08
	O			8.29	7.80			7.39	7.08
	N			7.93	8.11			7.59	5.55
	D			*	8.04			7.59	5.53
	Ave	6.86	6.78	7.20	7.49	7.46	7.66	6.03	5.74
1977	J			*	8.11			7.60	5.58
	F			7.87	8.12			7.20	5.74
	M			7.81	7.92			6.19	5.60
	A			7.58	7.84			7.52	5.54
	M			7.81	8.58			7.37	5.51
	J			7.70	8.05			7.60	5.12
	Ave			7.75	8.10			7.25	5.52

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*No data available

**New lift added

Table A-7. Leachate Calcium Hardness Concentration (mg $CaCO_3/\ell$)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell
	S	984	2480	2910	1970				
	O	598	3220	3078	2052				
	N	855	5130	*	513				
	D	1197	6228	2052	1539				
	Ave	908	4264	2680	1518				
1971	J	928	4375	1863	1755				
	F	775	4400	5200	4200				
	M	1350	4000	5000	3800				
	A	1250	3875	5200	4400				
	M	950	4800	4800	3600				
	J	750	4000	4200	2400				
	J	750	3600	2600	700				
	A	500	1900	700	500				
	S	600	1700	700	500				
	O	450	1500	800	600				
	N	450	1425	650	400				
	D	1000	4000	1700	600				
	Ave	813	3298	2784	1955				
1972	J	1000	3800	700	450				
	F	280	470	800	700				
	M	500	1200	1000	800				
	A	1015	3318	2561	1717				
	M	1144	3570	1087	756				
	J	859	3496	300	350				
	J	590	1410	389	424				
	A	939	1962	665	473	152	317	*	*
	S	928	1725	480	382	*	1595	7680	800
	O	1170	2338	644	468	3384	*	10060	7715
	N	695	1129	560	463	3450	2150	9628	1050
	D	520	1049	800	537	521	1126	8555	*
	Ave	803	2122	832	627	1877	1297	8981	3188
1973	J	508	868	625	471	2921	1015	2445	825
	F	704	907	637	522	2343	463	5465	943
	M	1657	4230	1263	515	2335	992	5891	1629
	A	1334	3460	1156	446	1955	793	6901	3789
	M	1440	4521	895	478	1675	682	8129	2888
	J	1064	4170	569	490	1219	831	8603	3965
	J	780	2971	520	444	789	834	6553	2538
	A	499	808	423	429	613	553	5855	2060
	S	514	544	444	615	516	521	5845	1766
	O	626	556	434	505	803	687	5820	1874
	N	837	1648	741	640	447	538	*	*
	D	511	1184	562	546	909	460	5576	3000
	Ave	873	2156	689	508	1377	697	6098	2298

Table A-7. Leachate Calcium Hardness Concentration (mg $CaCO_3/\ell$) (Continued)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
1974	J	319	704	508	664	747	431	4930	1165
	F	400	755	539	512	865	470	5413	2265
	M	707	1528	664	410	904	369	4659	2449
	A	674	1894	745	470	916	400	5313	3375
	M	721	1286	636	444	713	336	4636	2528
	J	576	927	543	464	735	445	4660	3101
	J	596	709	526	489	594	403	4275	2563
	A	439	647	414	647	521	329	4094	2873
	S	590	508	454	1107	738	412	4284	2554
	O	689	523	1063	1497	1323	604	4511	2827
	N	572	769	606	1441	1418	402	4068	2482
	D	528	786	492	973	641	371	4166	3008
	Ave	568	920	599	760	843	414	4584	2599
1975	J	512	633	470	1156	565	380	4196	2633
	F	796	560	998	*	1145	606	4482	*
	M	448	922	970	1276	1308	395	4771	2444
	A	550	1169	834	1232	642	328	4117	2457
	M	450	1495	639	525	329	324	3925	2658
	J	419	681	509	530	456	346	3460	2508
	J	425	627	** 416	** 383	468	406	3774	2657
	A	433	712	462	363	499	476	3683	2444
	S	523	597	405	302	500	496	3774	2981
	O	436	577	525	436	1451	471	4294	2619
	N	501	709	548	706	1417	972	3643	2772
	D	516	814	*	*	1503	839	3785	2621
	Ave	501	791	616	691	857	503	3992	2618
1976	J	1032	1030	*	965	1277	775	3822	3015
	F	999	1074	630	1391	1154	1000	4132	2260
	M	720	833	891	3768	638	829	3927	3910
	A	897	1085	1038	4460	894	598	8373	6264
	M	660	958	780	2483	403	477	5716	4550
	J			646	3506	543	479	3700	4426
	J			555	1905			2178	3141
	A			432	845			2527	3167
	S			566	2488			2909	2716
	O			702	1926			2266	3116
	N			1339	2288			2268	3752
	D			*	2464			2017	3976
	Ave	862	996	758	2374	818	693	3653	3691
1977	J			*	2214			2357	4537
	F			1543	1619			1332	1541
	M			1522	2133			1817	2756
	A			941	2731			1766	3190
	M			431	1911			1828	2869
	J			552	1372			1940	2301
	Ave			998	1997			1840	2866

*No data available

**New lift added

Table A-8. Leachate Total Hardness Concentration (mg $CaCO_3/\ell$)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
	S	1669	3420	4100	2650				
	O	1112	4916	4617	3078				
	N	1710	6156	*	1026				
	D	2052	7780	3078	2736				
	Ave	1636	5568	3932	2372				
1971	J	1594	6050	3189	3289				
	F	1375	6150	7600	6100				
	M	2250	5500	7000	5600				
	A	2000	5000	7000	6200				
	M	1500	5800	6800	5400				
	J	1300	5200	6000	4200				
	J	1200	4800	3600	1900				
	A	800	2400	1400	1600				
	S	900	2200	1400	1600				
	O	700	2000	1500	1800				
	N	800	2000	1200	1550				
	D	1600	5400	3000	1950				
	Ave	1335	4375	4141	3432				
1972	J	1600	4800	1700	1650				
	F	465	620	1400	1275				
	M	783	1600	1900	1900				
	A	1767	4510	3956	2969				
	M	1891	4846	2210	1787				
	J	1453	4556	1389	1179				
	J	1095	2002	709	1018				
	A	1579	2778	1365	1124	225	528	*	*
	S	1532	2430	993	977	*	2474	10850	1240
	O	1927	3382	1188	932	5483	*	14010	12210
	N	1431	2239	1256	1008	5772	3380	13735	1813
	D	1003	1617	1513	1151	2358	2095	12096	*
	Ave	1377	2948	1632	1414	3460	2119	12673	5088
1973	J	896	1317	1284	1018	5173	2115	7017	1426
	F	1203	1381	1267	1056	3995	1651	8039	1526
	M	2396	5815	2187	984	3659	1997	8619	2588
	A	2091	4826	1766	793	3192	1451	9818	5657
	M	2197	6237	1553	973	2812	1307	11628	4365
	J	1732	6141	1445	1056	2096	1440	12600	5611
	J	1279	4401	1186	822	1715	1576	9412	3872
	A	921	1849	868	822	1453	1185	8069	3228
	S	888	1171	867	956	1229	1092	7941	2893
	O	1092	1351	1029	1050	1688	1240	8164	2965
	N	1446	2567	1178	1069	1190	1055	*	*
	D	977	2197	1025	1019	1895	1016	7840	4602
	Ave	1426	3271	1305	968	2508	1427	9013	3521

Table A-8. Leachate Total Hardness Concentration (mg $CaCO_3/\ell$)(Continued)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
1974	J	574	1117	900	1137	1419	825	6851	1719
	F	690	1096	921	835	1730	812	6983	3458
	M	1198	2348	1105	701	1676	751	5646	3513
	A	1134	2721	1203	822	1561	696	6898	5143
	M	1204	1943	1101	749	1253	645	5990	3983
	J	942	1487	970	740	1278	768	5865	4772
	J	978	1268	989	730	1065	706	5309	3825
	A	719	1062	767	947	882	565	5212	4409
	S	891	890	842	1396	1159	734	5788	3821
	O	1067	903	1516	1914	1689	1046	5945	4114
	N	983	1347	967	1817	2061	683	4978	3439
	D	899	1129	887	1360	1100	707	5358	4736
	Ave	940	1443	1014	1096	1406	745	5902	3911
1975	J	935	1011	877	1464	880	647	5075	4730
	F	1248	910	1426	*	1609	984	6303	*
	M	744	1429	1435	1773	1731	682	5848	3706
	A	921	1857	1295	1783	1113	578	5091	3912
	M	846	2153	1047	820	604	584	5748	4391
	J	743	1058	899	828	807	675	4906	3798
	J	814	926	** 811	** 656	876	725	5002	4405
	A	673	1022	788	580	862	725	4585	3558
	S	810	850	894	536	708	755	5124	5055
	O	773	861	869	709	1892	868	4740	3947
	N	825	1029	954	990	1761	1489	4729	4416
	D	845	1452	*	*	1749	1248	5195	4142
	Ave	848	1213	1027	1014	1216	830	5196	4187
1976	J	1835	1671	*	1311	1601	1212	5956	5022
	F	1412	1497	1053	2087	1525	1453	7034	4657
	M	1424	1392	1609	6335	1072	1289	7491	6716
	A	1154	1744	1610	8660	1110	992	16772	15256
	M	1357	1407	1237	5333	949	889	11341	14196
	J			1353	5248	1057	1126	8287	7621
	J			1494	3551			4377	5018
	A			809	2705			4595	4961
	S			904	3682			4668	5000
	O			972	3880			3454	5426
	N			1676	4600			3539	6156
	D			*	5449			3885	8291
	Ave	1436	1542	1272	4403	1219	1160	6783	7360
1977	J			*	5202			4309	7752
	F			1826	3611			4352	3714
	M			1762	3469			3604	4349
	A			1218	4631			3396	5268
	M			675	2964			2757	5211
	J			1025	3198			3491	4355
	Ave			1301	3846			3652	5108

*No data available

**New lift added

Table A-9. Leachate Alkalinity (mg Ca CO_3/ℓ)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
	S	1925	2960	3920	2430				
	O	1606	4405	4557	3454				
	N	1966	6184	*	1230				
	D	2538	6988	3089	2689				
	Ave	2009	5134	3855	2451				
1971	J	2274	5724	4676	4206				
	F	1793	5184	7803	7182				
	M	3221	4966	8258	7190				
	A	2859	4851	7508	7046				
	M	2368	5544	7623	6583				
	J	2350	5603	7832	6266				
	J	2100	5562	5562	5334				
	A	1284	2558	2996	4387				
	S	1525	2996	3317	4574				
	O	1177	2568	2836	3210				
	N	931	2568	2408	4280				
	D	2565	5830	4505	4558				
	Ave	2037	4496	5444	5401				
1972	J	2756	5724	3710	4558				
	F	673	763	1431	1086				
	M	1242	2000	2632	2697				
	A	3081	5187	5130	4040				
	M	3013	5412	4015	3257				
	J	2576	5202	3926	2955				
	J	4489	4259	4276	4242				
	A	2855	3861	2656	2343	273	577	*	*
	S	2642	3236	2219	2257	*	4219	941	188
	O	2793	4704	2318	1755	9089	*	15195	1862
	N	3600	4416	2870	1762	9384	6027	14259	2623
	D	2095	2683	2499	1740	8820	5096	13524	*
	Ave	2651	3954	3140	2724	6892	3980	10980	1558
1973	J	1641	2017	2206	1467	8036	5586	7571	1911
	F	2435	2139	2219	1722	6958	4774	9267	2414
	M	3978	6853	2985	1385	5745	4865	9044	3696
	A	3016	5616	2228	1060	5147	3118	9810	6208
	M	3139	7457	2500	1364	4773	2898	12358	5469
	J	2738	7689	3219	1748	4853	3859	13507	6455
	J	2519	5969	2877	1546	4398	3419	9846	4881
	A	1776	4125	2204	1342	4483	3051	8116	4356
	S	1323	2214	1711	1165	4819	3675	11644	5550
	O	2128	3450	2041	1596	5325	4219	7461	4126
	N	1519	3680	1157	948	2662	1422	*	*
	D	1769	3738	1769	1265	3709	2070	8525	6484
	Ave	2332	4579	2260	1384	5076	3580	9741	4686

Table A-9. Leachate Alkalinity (mg $CaCO_3/\ell$) (Continued)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
1974	J	863	1826	1078	877	3407	1610	6483	2114
	F	1004	1465	1126	909	3476	1731	6399	4172
	M	1397	2794	1451	828	3307	1582	5549	5218
	A	1586	3235	1534	1096	2904	1582	6469	6311
	M	1777	2485	1468	979	2112	1082	5242	4726
	J	1648	2331	1481	1056	2318	1442	4121	5331
	J	1832	2537	1691	1000	2472	1468	4352	4841
	A	1307	2243	1320	987	1922	1166	5162	6125
	S	1346	2306	1564	666	1320	1166	5215	5497
	O	1115	2026	871	500	526	513	5702	5958
	N	1845	2358	1295	654	525	705	5407	5279
	D	1691	1858	1384	577	1602	615	4997	6048
	Ave	1451	2289	1355	844	2158	1222	5425	5135
1975	J	1290	1581	1350	453	1110	410	4946	5492
	F	590	1273	453	*	452	368	5800	*
	M	1123	1981	833	526	251	445	5820	5028
	A	1415	2579	1706	679	1608	582	5465	5181
	M	1261	2700	1471	873	873	704	4778	5053
	J	1027	1296	1120	860	1176	768	4440	4824
	J	1376	1427	** 1236	** 959	*	*	*	*
	A	1218	1596	1277	915	1360	782	4856	5016
	S	1362	1644	1362	1021	940	564	4300	5196
	O	1037	1523	988	790	349	622	4398	4701
	N	808	973	883	774	214	494	3786	4526
	D	1265	1829	*	*	291	202	4282	5010
	Ave	1148	1700	1153	785	784	540	4806	5003
1976	J	410	953	*	755	233	277	4433	7714
	F	338	704	1306	1552	182	365	4729	3358
	M	1234	1063	1573	5609	526	321	6144	6909
	A	1107	1327	1700	6377	626	362	6350	6650
	M	1236	1480	1471	5849	799	351	4889	5827
	J			1372	5750	940	401	4288	5394
	J			1334	4947			3568	5038
	A			1046	4393			3890	5341
	S			891	3586			3011	6797
	O			891	3856			3011	6797
	N			816	2388			3471	7254
	D			*	1847			2582	6894
	Ave	865	1105	1240	3909	551	346	4197	6164
1977	J			*	1693			2504	6906
	F			653	509			1958	3314
	M			744	1777			2119	3686
	A			1325	5280			2225	6580
	M			1064	3802			1811	2150
	J			1068	4704			2208	3224
	Ave			971	2961			2138	4310

*No data available

**New lift added

Table A-10. Leachate Chloride Concentration (mg/ℓ)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
	S	515	530	834	605				
	O	330	666	960	600				
	N	288	1005	*	132				
	D	625	375	1375	1562				
	Ave	440	644	1056	725				
1971	J	332	613	1052	1210				
	F	322	906	1626	1613				
	M	712	850	1700	1550				
	A	562	938	1700	1562				
	M	425	925	1400	1300				
	J	475	900	1550	1425				
	J	372	769	992	1364				
	A	198	273	595	1017				
	S	200	250	700	1150				
	O	229	229	782	1105				
	N	282	330	552	1320				
	D	593	916	1105	1105				
	Ave	392	658	1146	1310				
1972	J	570	829	1010	1140				
	F	181	142	453	486				
	M	258	405	550	580				
	A	589	881	1003	735				
	M	650	914	984	685				
	J	923	1394	1503	942				
	J	499	446	591	585				
	A	472	542	513	446	5	566	*	*
	S	548	587	479	432	*	1247	2073	442
	O	834	974	575	342	1685	*	2448	365
	N	709	902	663	307	1974	1592	2578	534
	D	389	470	498	278	2003	1258	2449	*
	Ave	552	707	735	580	1417	1166	2387	447
1973	J	364	354	465	216	2095	1534	1393	417
	F	402	343	459	240	1698	1636	1542	483
	M	700	984	519	143	1225	1228	1510	787
	A	523	764	350	89	1203	913	1697	1164
	M	504	1087	430	80	1002	945	2100	970
	J	478	1052	639	195	1371	1157	3270	1527
	J	402	852	440	127	881	686	1410	778
	A	302	780	350	142	813	644	1068	571
	S	188	294	248	117	862	670	1117	576
	O	322	651	304	171	944	655	1328	669
	N	330	662	206	132	825	643	*	*
	D	345	654	227	63	755	551	1027	1045
	Ave	405	706	386	143	1140	938	1587	817

Table A-10. Leachate Chloride Concentration (mg/ℓ) (Continued)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
1974	J	129	263	133	69	731	552	844	408
	F	152	162	115	69	630	406	843	724
	M	261	298	140	47	526	388	584	824
	A	247	474	232	75	462	293	726	1164
	M	217	337	173	38	341	219	538	969
	J	198	330	179	70	331	229	398	966
	J	208	352	217	72	335	266	233	746
	A	164	283	124	27	320	275	310	991
	S	178	230	162	59	245	161	466	892
	O	183	154	124	26	228	230	372	776
	N	239	270	105	43	262	284	263	778
	D	212	190	96	27	307	262	257	936
	Ave	199	279	150	52	393	297	486	848
1975	J	204	129	135	12	249	262	640	1088
	F	145	56	90	*	223	284	400	*
	M	108	103	78	70	216	247	182	476
	A	158	154	103	42	194	277	365	755
	M	155	243	108	25	144	214	273	719
	J	177	217	98	70	136	175	25	517
	J	45	58	** 69	** 4	204	225	397	999
	A	147	215	233	68	173	197	427	760
	S	147	133	143	26	197	181	360	1426
	O	168	165	131	73	144	193	223	1499
	N	168	109	189	138	114	157	606	1056
	D	169	160	*	*	112	165	171	634
	Ave	149	145	125	53	176	215	339	903
1976	J	192	107	*	203	125	155	295	920
	F	154	59	214	647	147	172	267	449
	M	156	114	326	1378	81	137	97	810
	A	203	210	336	2187	202	148	1144	2480
	M	161	183	256	1963	204	135	635	1402
	J			221	1638	135	121	638	814
	J			173	1650			1385	1700
	A			173	1671			490	1109
	S			178	2171			734	1134
	O			131	1352			162	988
	N			173	1176			538	933
	D			*	1604			155	1310
	Ave	173	135	219	1470	149	145	545	1171
1977	J			*	1044			102	946
	F			82	1035			393	601
	M			80	1060			439	642
	A			171	1025			127	851
	M			176	1164			106	647
	J			183	1784			166	810
	Ave			138	1185			222	750

*No data available

**New lift added.

Table A-11. Leachate Total Iron Concentration (mg/ℓ)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
	S	*	*	*	*				
	O	69	266	234	125				
	N	*	*	*	*				
	D	71	326	43	106				
	Ave	70	296	138	116				
1971	J	54	303	304	164				
	F	55	414	619	350				
	M	93	408	668	281				
	A	90	420	695	426				
	M	95	523	750	315				
	J	72	476	865	235				
	J	109	620	368	42				
	A	119	465	44	31				
	S	104	275	20	4				
	O	49	232	13	44				
	N	44	333	62	27				
	D	134	695	194	45				
	Ave	85	430	384	164				
1972	J	134	635	33	13				
	F	42	46	77	25				
	M	153	171	266	189				
	A	125	417	488	337				
	M	112	573	147	99				
	J	89	590	41	51				
	J	82	362	32	33				
	A	164	550	70	38	6	15	*	*
	S	197	396	70	38	*	150	520	53
	O	172	465	105	73	74	*	805	68
	N	63	116	39	46	156	179	830	93
	D	108	249	292	189	130	34	720	*
	Ave	120	381	138	94	92	94	719	71
1973	J	113	205	112	76	99	17	444	55
	F	105	152	102	72	128	33	564	55
	M	346	1195	284	98	177	26	630	102
	A	375	1198	269	102	170	38	693	300
	M	405	1577	126	100	181	48	938	286
	J	211	1329	29	58	121	28	1057	434
	J	166	763	29	40	73	53	768	378
	A	55	65	24	32	43	17	637	317
	S	80	65	29	44	8	16	640	312
	O	69	31	5	39	48	27	788	380
	N	80	287	91	50	192	8	*	*
	D	100	109	85	54	66	33	968	406
	Ave	175	581	99	64	109	29	739	275

Table A-11. Leachate Total Iron Concentration (mg/ℓ)(Continued)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
1974	J	106	116	109	66	53	35	973	156
	F	94	200	157	55	84	47	940	263
	M	164	658	242	77	104	44	793	232
	A	237	532	172	93	102	38	840	314
	M	271	356	143	75	132	43	808	311
	J	156	152	77	133	109	55	851	403
	J	84	37	37	45	57	26	3169	440
	A	65	41	37	53	25	13	849	478
	S	55	31	24	18	42	11	854	909
	O	108	37	105	88	112	31	922	498
	N	105	74	58	77	121	20	1017	578
	D	56	70	54	34	54	14	1094	622
	Ave	125	192	101	68	83	31	1092	434
1975	J	56	86	46	50	17	8	955	459
	F	56	81	66	*	17	4	1230	*
	M	156	483	102	48	34	6	1157	430
	A	147	607	280	45	90	11	988	419
	M	92	473	129	63	24	5	929	283
	J	98	97	71	213	77	14	1142	419
	J	147	75	** 54	** 101	34	8	1228	525
	A	92	74	70	89	95	16	500	562
	S	75	49	46	72	42	4	1262	516
	O	67	44	68	71	46	39	1291	540
	N	59	99	53	41	154	6	1316	580
	D	72	28	*	*	16	5	1567	624
	Ave	93	183	90	79	54	10	1130	487
1976	J	50	116	*	54	12	6	1372	703
	F	200	201	42	38	5	52	2787	374
	M	192	316	83	397	8	4	5420	1072
	A	198	292	54	236	17	4	1381	456
	M	111	156	84	136	47	6	1259	1237
	J			59	47	38	13	1272	458
	J			63	18			1655	443
	A			43	23			1355	838
	S			51	24			1083	718
	O			37	69			428	670
	N			34	31			239	624
	D			*	30			269	662
	Ave	150	216	55	92	21	14	1543	688
1977	J			*	69			128	400
	F			128	23			312	318
	M			253	15			735	158
	A			63	194			269	343
	M			91	56			180	270
	J			76	36			105	431
	Ave			122	66			288	320

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*No data available

**New lift added

Table A-12. Leachate Ammonia-N Concentration (mg N/ℓ)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
	S	186	187	205	132				
	O	172	240	336	176				
	N	200	386	*	35				
	D	271	476	206	141				
	Ave	207	322	249	121				
1971	J	216	368	337	234				
	F	214	307	500	474				
	M	316	254	483	526				
	A	293	306	505	530				
	M	228	354	522	484				
	J	240	362	556	455				
	J	215	333	388	413				
	A	154	162	246	368				
	S	168	137	274	411				
	O	151	130	263	373				
	N	147	119	145	307				
	D	309	418	267	309				
	Ave	221	271	374	407				
1972	J	295	390	214	316				
	F	67	47	112	149				
	M	144	164	154	119				
	A	268	327	305	220				
	M	293	353	271	177				
	J	231	379	305	182				
	J	203	222	225	306				
	A	258	222	173	138	6	69	*	*
	S	295	218	136	132	*	638	676	279
	O	427	351	111	58	1073	*	1055	237
	N	348	397	164	46	1217	1036	1013	361
	D	212	228	105	11	1340	745	1118	*
	Ave	253	275	190	154	909	622	966	292
1973	J	147	137	81	28	1036	703	629	290
	F	208	135	84	24	914	429	770	353
	M	387	363	139	25	694	622	664	497
	A	256	295	74	15	634	323	706	582
	M	315	450	136	61	551	269	818	639
	J	318	501	276	68	582	387	935	735
	J	275	471	278	87	580	346	703	687
	A	162	461	191	64	567	262	643	657
	S	100	244	128	38	488	217	695	535
	O	162	368	38	74	401	321	663	618
	N	98	308	32	24	215	99	*	*
	D	94	292	48	26	303	96	647	794
	Ave	210	335	125	44	580	340	716	581

Table A-12. Leachate Ammonia-N Concentration (mg N/ℓ) (Continued)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
1974	J	31	120	16	10	272	62	509	324
	F	35	65	12	8	283	72	515	614
	M	81	100	20	9	258	49	351	634
	A	88	172	44	21	226	73	480	825
	M	92	131	36	14	176	40	337	601
	J	95	132	54	29	171	67	295	630
	J	119	189	88	28	220	69	239	651
	A	98	206	72	30	157	38	240	739
	S	132	221	87	34	138	9	307	669
	O	91	202	68	30	59	13	300	700
	N	88	124	74	24	58	8	249	651
	D	81	69	51	7	54	7	221	361
	Ave	86	144	52	20	173	42	337	617
1975	J	64	54	54	10	22	4	236	703
	F	62	55	47	*	13	6	263	*
	M	32	33	29	5	12	2	227	665
	A	44	42	26	9	52	3	258	647
	M	59	58	32	5	22	2	218	646
	J	67	60	54	15	35	0	164	646
	J	67	55	** 68	** 42	63	0	154	698
	A	74	81	76	64	69	2	159	648
	S	99	95	90	67	56	0	92	625
	O	110	120	94	72	42	10	74	339
	N	93	88	69	50	10	5	60	290
	D	56	63	*	*	18	2	174	717
	Ave	69	59	58	34	34	3	173	602
1976	J	39	45	*	30	12	5	164	790
	F	16	16	72	57	6	12	68	179
	M	37	14	56	455	6	2	164	696
	A	29	12	70	595	16	1	118	655
	M	38	31	72	721	16	1	118	655
	J			82	760	31	0	95	490
	J			72	637			104	637
	A			82	600			82	622
	S			64	644			92	764
	O			52	640			94	833
	N			33	324			99	804
	D			*	327			96	891
	Ave	32	24	66	482	14	4	108	668
1977	J			*	250			86	948
	F			15	24			67	506
	M			12	127			52	517
	A			60	453			49	554
	M			60	453			49	554
	J			62	563			80	573
	Ave			42	312			64	609

*No data available

**New lift added

Table A-13. Leachate Organic-N Concentration (mg N/ℓ)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
	S	133	130	282	112				
	O	46	70	112	60				
	N	46	132	*	18				
	D	51	162	105	102				
	Ave	69	124	166	73				
1971	J	37	96	82	100				
	F	56	202	448	342				
	M	88	228	281	167				
	A	68	168	303	154				
	M	30	135	160	*				
	J	38	135	194	92				
	J	25	97	61	67				
	A	18	44	40	57				
	S	21	32	32	53				
	O	39	24	44	44				
	N	24	24	22	53				
	D	39	161	56	46				
	Ave	40	112	144	107				
1972	J	39	109	42	39				
	F	21	20	22	26				
	M	24	35	32	35				
	A	46	105	58	41				
	M	46	104	44	37				
	J	39	82	51	33				
	J	18	29	23	23				
	A	22	60	42	27	3	87	*	*
	S	42	54	36	27	*	201	898	103
	O	94	81	41	25	217	*	919	81
	N	60	56	33	20	239	242	1061	99
	D	37	44	46	13	210	168	1034	*
	Ave	41	65	39	29	167	174	978	94
1973	J	42	31	32	22	226	145	526	115
	F	28	29	29	20	223	91	616	99
	M	128	278	49	31	266	116	786	264
	A	81	196	34	20	183	86	802	459
	M	84	295	31	36	100	51	1013	252
	J	51	216	46	16	102	56	1140	285
	J	34	118	38	16	100	60	727	199
	A	69	70	25	14	91	42	518	185
	S	18	38	23	19	66	38	355	144
	O	22	39	6	17	71	50	290	304
	N	36	59	27	17	39	20	*	*
	D	22	46	15	12	62	34	343	389
	Ave	51	118	30	20	127	66	647	245

Table A-13. Leachate Organic-N Concentration (mg N/ℓ)(Continued)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
1974	J	9	14	14	15	37	24	281	114
	F	15	24	19	11	38	26	280	246
	M	25	34	22	13	26	21	191	271
	A	18	42	23	12	30	21	253	434
	M	21	38	23	11	31	23	179	334
	J	16	33	19	10	33	20	168	392
	J	21	38	19	12	33	21	126	284
	A	18	35	15	11	30	20	132	331
	S	20	37	16	11	35	6	167	278
	O	15	32	16	8	14	16	157	284
	N	24	32	19	10	16	15	126	282
	D	19	25	21	11	21	17	139	181
	Ave	18	32	19	11	29	19	183	286
1975	J	15	18	16	8	14	16	166	314
	F	15	16	15	*	13	14	169	*
	M	16	24	21	16	11	28	203	259
	A	24	25	17	13	18	28	151	248
	M	14	26	19	13	13	25	146	309
	J	13	18	11	5	10	22	97	233
	J	17	15	** 24	** 19	18	19	115	211
	A	10	15	21	14	20	15	113	241
	S	8	14	18	15	2	4	37	200
	O	15	24	19	18	11	23	52	110
	N	18	22	20	20	9	14	38	92
	D	9	16	*	*	10	14	93	223
	Ave	14	19	18	14	12	18	115	222
1976	J	10	13	*	8	9	13	80	266
	F	9	8	12	33	9	28	33	45
	M	15	14	14	82	20	9	89	314
	A	15	14	15	103	20	12	72	258
	M	23	17	17	123	20	12	72	258
	J			17	116	12	19	54	316
	J			15	114			48	267
	A			0	92			43	224
	S			5	36			35	222
	O			12	115			58	248
	N			18	47			60	249
	D			*	48			40	274
	Ave	14	13	12	76	15	16	57	245
1977	J			*	36			31	252
	F			13	41			29	115
	M			10	58			42	231
	A}			11	81			34	208
	M}			11	81			34	208
	J			14	117			48	172
	Ave			12	69			36	198

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*No data available

**New lift added

Table A-14. Leachate Ammonium-N Concentration (mg N/ℓ)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
	S	*	*	*	*				
	O	*	*	*	*				
	N	*	*	*	*				
	D	*	*	*	*				
	Ave								
1971	J	*	*	*	*				
	F	*	*	*	*				
	M	*	*	*	*				
	A	324	328	560	590				
	M	228	354	522	584				
	J	240	362	568	468				
	J	*	*	*	*				
	A	*	*	*	*				
	S	*	*	*	*				
	O	*	*	*	*				
	N	*	*	*	*				
	D	*	*	*	*				
	Ave	264	348	550	547				
1972	J	*	*	*	*				
	F	*	*	*	*				
	M	*	*	*	*				
	A	*	*	*	*				
	M	*	*	*	*				
	J	*	*	*	*				
	J	*	*	*	*				
	A	283	261	194	158	*	*	*	*
	S	292	223	138	132	*	628	640	274
	O	404	193	118	58	1090	*	999	241
	N	370	416	175	55	1245	1055	1034	422
	D	208	219	112	27	357	204	310	*
	Ave	311	262	147	86	897	629	746	312
1973	J	157	133	85	21	1055	671	644	288
	F	205	138	87	27	911	441	744	357
	M	370	358	142	30	674	591	647	471
	A	257	297	79	23	598	320	681	587
	M	305	451	133	32	548	258	822	656
	J	326	515	281	65	576	397	938	747
	J	269	474	269	83	588	358	699	667
	A	166	468	202	70	588	270	651	604
	S	113	258	135	45	672	284	924	714
	O	161	370	161	77	525	431	*	*
	N	94	312	31	62	234	109	692	596
	D	97	290	56	32	290	105	628	773
	Ave	210	339	138	47	605	353	734	587

Table A-14. Leachate Ammonium-N Concentration (mg N/ℓ)(Continued)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
1974	J	40	129	24	16	257	72	547	338
	F	46	76	23	15	286	79	508	620
	M	91	114	23	15	274	56	386	676
	A	94	180	50	29	250	89	499	869
	M	65	144	43	22	180	43	346	620
	J	101	144	65	36	202	72	317	678
	J	129	194	93	36	231	72	245	663
	A	100	201	79	36	172	50	273	732
	S	136	222	93	36	144	50	316	674
	O	208	215	72	29	72	22	316	718
	N	86	115	72	22	72	14	258	646
	D	86	79	65	14	61	14	244	789
	Ave	98	151	58	26	183	53	355	669
1975	J	72	57	65	14	36	14	273	703
	F	64	57	43	*	14	14	273	*
	M	34	41	41	7	20	14	285	652
	A	48	48	27	14	61	7	272	679
	M	68	61	34	14	34	7	231	625
	J	67	60	54	13	40	13	161	578
	J	81	67	** 108	** 47	59	7	188	672
	A	87	94	94	81	114	7	155	605
	S	105	120	105	83	54	7	148	632
	O	114	121	87	74	35	41	140	612
	N	92	92	63	49	7	7	166	719
	D	66	73	*	*	21	0	183	689
	Ave	75	74	66	40	41	12	206	651
1976	J	27	35	*	17	18	10	170	729
	F	67	27	78	78	4	16	40	84
	M	35	15	57	457	8	0	78	350
	A	28	15	75	236	16	0	218	747
	M	42	39	75	691	21	0	581	3180
	J			81	689	40	14	66	389
	J			80	589			76	617
	A			67	595			644	346
	S			54	637			101	825
	O			54	637			101	825
	N			32	299			62	735
	D			*	302			92	861
	Ave	40	26	65	436	18	7	186	807
1977	J			*	238			93	933
	F			15	26			66	500
	M			12	131			59	504
	A			59	434			26	592
	M			56	394			34	570
	J			64	558			87	538
	Ave			41	297			61	606

*No data available

**New lift added

Table A-15. Leachate Nitrate-N Plus Nitrite-N Concentration (mg N/ℓ)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
	S	*	*						
	O	*	*						
	N	*	*						
	D	*	*						
	Ave								
1971	J	*	*	*	*				
	F	*	*	*	*				
	M	*	*	*	*				
	A	31.0	22.0	55.0	60.0				
	M	8.0	12.0	30.0	22.0				
	J	0.0	0.0	12.0	13.0				
	J	*	*	*	*				
	A	*	*	*	*				
	S	*	*	*	*				
	O	*	*	*	*				
	N	*	*	*	*				
	D	*	*	*	*				
	Ave	13.0	11.3	32.3	31.7				
1972	J	*	*	*	*				
	F	*	*	*	*				
	M	*	*	*	*				
	A	*	*	*	*				
	M	*	*	*	*				
	J	*	*	*	*				
	J	*	*	*	*				
	A	3.9	0.0	0.3	0.3	*	*	*	*
	S	1.3	0.7	0.4	0.1	*	4.8	3.8	1.5
	O	1.1	0.0	0.0	0.0	9.6	*	19.0	3.5
	N	0.0	0.0	0.0	0.0	5.5	0.0	28.0	1.5
	D	0.0	0.0	0.0	0.0	4.0	0.0	0.0	*
	Ave	1.3	0.1	0.1	0.1	6.4	1.6	12.7	2.2
1973	J	0.3	0.2	0.2	0.2	2.3	1.9	0.0	1.1
	F	0.5	1.5	0.0	0.0	0.0	0.0	0.0	0.0
	M	0.0	0.0	0.0	1.2	0.0	0.0	0.8	0.0
	A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	J	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	J	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	A	1.0	0.8	0.0	0.7	0.0	0.0	0.0	0.0
	S	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0
	O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	N	3.3	3.9	2.6	3.9	11.9	12.8	*	*
	D	0.0	0.0	0.0	0.0	0.0	5.6	0.0	0.0
	Ave	0.4	0.4	0.2	0.7	1.2	1.7	0.1	0.1

Table A-15. Leachate Nitrate-N Plus Nitrite-N Concentration (mg N/ℓ)(Continued)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
1974	J	0.0	0.0	0.0	0.0	0.0	6.1	0.0	0.0
	F	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0
	M	0.0	0.0	0.0	0.0	0.0	6.1	0.0	0.0
	A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	J	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	J	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	D	0.0	0.0	0.0	5.9	0.0	0.0	0.0	0.0
	Ave	0.0	0.0	0.0	0.5	0.0	1.2	0.0	0.0
1975	J	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	F	0.0	1.6	0.0	*	2.0	4.3	0.0	*
	M	0.0	0.0	0.0	0.0	0.0	27.0	0.0	0.0
	A	0.0	0.0	0.0	0.0	0.0	8.7	0.0	0.0
	M	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0
	J	0.0	0.0	0.0	0.0	0.0	22.7	0.0	0.0
	J	0.0	0.0	** 0.0	** 0.0	0.0	4.5	0.0	0.0
	A	0.0	0.0	0.0	0.0	1.2	0.4	0.0	1.2
	S	0.0	0.0	0.0	0.0	4.9	32.0	6.5	12.2
	O	0.0	0.0	1.2	1.2	4.0	2.0	0.0	0.0
	N	4.1	3.3	3.3	4.9	2.9	152.0	0.0	2.5
	D	1.6	1.2	*	*	3.3	153.0	2.5	0.8
	Ave	0.5	0.5	0.4	0.6	1.5	35.6	0.8	1.5
1976	J	1.7	0.0	*	0.0	2.9	98.4	0.8	0.0
	F	2.3	0.4	0.8	0.0	56.6	47.4	0.0	3.2
	M	0.0	0.0	0.4	0.0	19.2	136.0	0.0	0.0
	A	0.0	0.0	0.0	3.3	2.8	51.0	9.5	4.7
	M	2.8	0.0	6.8	135.0	0.8	32.8	4.9	6.6
	J			0.4	0.0	0.3	30.0	8.6	0.0
	J			0.0	0.0			0.0	0.0
	A			5.6	44.0			56.0	116.0
	S			0.4	11.9			4.0	8.0
	O			0.4	11.9			4.0	8.0
	N			0.0	3.9			3.9	0.0
	D			*	7.9			7.9	0.0
	Ave	1.4	0.1	1.5	18.2	13.8	65.9	8.3	12.2
1977	J			*	4.0			8.1	12.1
	F			0.0	24.4			0.0	0.0
	M			0.2	54.5			0.0	8.8
	A			1.3	6.6			0.0	0.0
	M			0.0	0.0			24.5	0.0
	J			0.0	0.0			0.0	0.0
	Ave			0.3	14.9			5.4	3.5

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*No data available

**New lift added

Table A-16. Leachate Total Phosphate Concentration (mg PO_4/ℓ)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
	S	72.0	58.0	86.0	51.0				
	O	62.0	38.0	34.0	45.0				
	N	32.0	38.0	*	7.0				
	D	33.0	62.0	33.0	24.0				
	Ave	49.8	49.0	51.0	31.8				
1971	J	28.0	22.0	11.5	19.0				
	F	46.0	78.0	80.0	71.0				
	M	46.0	128.0	65.0	30.0				
	A	36.0	31.0	20.0	11.0				
	M	30.0	39.0	15.0	10.0				
	J	24.0	18.0	14.0	8.0				
	J	31.0	16.0	7.0	14.0				
	A	20.0	12.0	6.2	7.2				
	S	27.0	11.0	4.6	7.2				
	O	11.0	4.4	7.1	4.5				
	N	22.0	2.6	2.2	7.0				
	D	15.0	13.0	7.2	5.0				
	Ave	28.0	31.2	20.0	16.2				
1972	J	28.0	10.7	8.4	6.8				
	F	4.6	4.8	2.8	3.9				
	M	12.3	4.4	4.1	3.8				
	A	12.2	7.6	3.3	2.6				
	M	10.9	7.5	4.3	4.5				
	J	10.9	5.0	5.0	3.4				
	J	13.5	6.0	3.0	3.2				
	A	13.0	9.6	3.9	5.0	2.8	91.0	*	*
	S	11.4	8.2	3.4	5.2	*	145.0	201.0	108.0
	O	11.0	6.5	3.5	2.4	48.0	*	79.0	74.0
	N	19.3	6.9	3.3	2.6	41.0	134.0	70.0	87.0
	D	5.5	2.9	4.8	3.0	45.0	55.0	63.0	*
	Ave	12.7	6.7	4.2	3.9	34.2	106.2	103.2	89.7
1973	J	5.8	3.3	3.8	3.5	27.0	63.0	37.0	49.0
	F	6.0	3.0	3.0	2.3	28.0	68.0	46.0	65.0
	M	8.4	31.0	4.9	5.3	38.0	77.0	88.0	46.0
	A	6.4	17.7	4.7	4.3	30.0	51.0	81.0	46.0
	M	4.0	10.3	3.0	2.4	25.0	39.0	85.0	45.0
	J	4.7	8.6	4.8	3.0	25.0	45.0	56.0	37.0
	J	5.0	6.1	5.1	4.1	23.0	36.0	28.0	57.0
	A	40.0	5.4	6.0	4.0	9.9	29.0	28.0	73.0
	S	4.5	6.1	3.8	3.3	10.8	14.7	16.4	41.0
	O	2.3	3.5	3.7	4.1	8.9	17.3	11.5	63.0
	N	5.4	3.9	5.0	3.4	17.3	7.7	*	*
	D	1.7	0.7	2.2	2.4	10.1	14.1	15.5	48.0
	Ave	7.8	8.3	4.2	3.5	21.1	38.5	44.8	51.8

Table A-16. Leachate Total Phosphate Concentration (mg PO_4/ℓ) (Continued)

Year	Month	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
1974	J	2.5	2.1	2.7	2.3	3.8	4.5	19.0	33.0
	F	3.3	1.4	3.6	1.1	7.5	13.3	25.0	40.0
	M	3.8	3.6	4.1	2.5	4.2	6.8	18.9	17.0
	A	2.7	3.1	3.4	2.9	3.4	9.3	19.3	36.0
	M	3.9	4.3	4.0	3.1	9.5	15.7	26.0	30.0
	J	4.0	5.4	2.3	4.0	4.3	6.4	14.2	17.8
	J	6.3	7.5	3.4	3.0	3.6	7.4	15.7	4.2
	A	8.8	5.5	1.5	3.3	2.5	12.1	24.0	15.0
	S	2.0	5.3	4.0	2.8	4.1	12.5	42.0	9.8
	O	1.5	6.0	2.0	2.3	5.0	5.5	30.0	21.0
	N	2.0	1.0	0.3	1.8	3.0	6.4	34.0	21.0
	D	6.6	1.1	2.5	2.5	2.8	3.5	6.5	19.5
	Ave	4.0	3.9	2.8	2.6	4.5	8.6	22.9	22.0
1975	J	2.6	1.7	1.7	0.6	0.0	2.3	36.0	23.0
	F	1.1	1.9	1.3	*	3.5	3.4	46.0	*
	M	4.2	4.8	2.9	3.4	0.6	5.3	28.0	25.0
	A	3.9	4.0	3.2	2.6	3.2	7.8	26.0	24.0
	M	2.9	3.0	2.9	2.0	2.9	7.5	25.0	26.0
	J	4.8	2.6	2.3	2.7	1.2	7.7	24.1	18.7
	J	4.0	2.7	** 4.9	** 4.4	4.6	4.1	24.9	15.8
	A	4.2	1.3	5.2	3.7	6.0	2.0	28.2	25.2
	S	3.9	4.2	6.0	8.2	5.6	2.2	38.8	23.5
	O	3.6	2.8	3.5	1.7	1.6	10.6	26.7	24.4
	N	2.9	3.6	3.6	2.8	0.6	2.5	26.5	24.7
	D	3.4	2.5	*	*	0.9	6.3	27.6	26.1
	Ave	3.5	2.9	3.4	3.2	2.6	5.1	29.8	23.3
1976	J	0.5	1.9	*	0.5	0.8	1.9	27.6	23.6
	F	1.7	2.0	2.0	3.7	0.8	3.9	26.7	21.6
	M	2.4	2.3	1.5	9.6	1.6	3.4	33.3	28.2
	A	3.2	2.9	2.2	13.0	1.9	6.0	29.2	23.3
	M	3.3	2.0	1.1	5.6	4.1	3.7	31.9	15.8
	J			2.2	9.2	2.0	7.8	25.8	16.0
	J			2.1	8.4			23.2	16.6
	A			2.2	8.4			24.2	15.4
	S			2.2	7.2			23.7	17.6
	O			1.5	8.2			11.3	21.0
	N			2.2	3.7			11.2	21.5
	D			*	2.1			6.1	19.2
	Ave	2.2	2.2	1.9	6.6	1.9	4.4	22.9	20.0
1977	J			*	7.0			7.5	15.8
	F			1.3	2.3			7.2	12.9
	M			1.3	6.3			7.3	19.0
	A			1.4	4.6			6.2	14.3
	M			0.9	8.1			8.4	16.4
	J			0.8	10.1			7.5	9.6
	Ave			1.1	6.4			7.4	14.7

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*No data available

**New lift added

Table A-17. Leachate Soluble Phosphate Concentration (mg PO_4/ℓ)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
	S	0.0	0.0	0.0	0.0				
	O	0.0	0.0	0.0	0.0				
	N	0.0	0.0	*	0.0				
	D	29.0	44.0	13.0	17.0				
	Ave	7.2	11.0	4.3	4.2				
1971	J	23.0	20.0	9.0	13.5				
	F	30.0	65.0	24.0	32.0				
	M	33.0	68.0	23.0	10.0				
	A	29.0	26.0	12.0	7.5				
	M	3.8	10.0	5.0	0.0				
	J	0.7	9.0	4.7	0.0				
	J	6.9	3.8	1.1	0.5				
	A	12.0	2.5	0.0	0.0				
	S	4.0	0.0	1.6	4.5				
	O	5.0	0.0	3.2	3.2				
	N	2.9	0.0	0.0	0.0				
	D	0.0	8.0	0.0	0.0				
	Ave	12.5	17.7	7.0	5.9				
1972	J	6.2	5.2	1.4	1.5				
	F	1.3	1.1	0.8	0.9				
	M	1.0	1.2	0.6	1.0				
	A	2.0	5.7	1.4	1.3				
	M	3.3	5.1	0.9	0.6				
	J	0.9	1.3	0.0	0.8				
	J	1.5	0.6	0.3	0.5				
	A	1.1	0.8	0.8	0.1	1.8	49.0	*	*
	S	0.2	0.5	0.0	0.9	*	28.0	11.2	2.3
	O	0.8	0.2	0.0	0.0	6.0	*	41.0	16.0
	N	0.1	0.0	0.0	0.0	4.0	30.2	26.4	15.8
	D	1.2	0.8	1.0	0.5	4.0	23.4	30.0	*
	Ave	1.6	1.9	0.6	0.7	4.0	32.6	27.2	11.4
1973	J	0.9	0.4	0.5	1.0	6.3	30.0	18.0	41.0
	F	0.9	1.0	0.5	0.5	10.2	31.0	24.0	49.0
	M	4.4	20.6	1.0	0.2	13.2	32.0	46.0	22.0
	A	2.3	10.3	1.1	0.9	12.2	18.5	60.0	28.0
	M	1.8	4.5	0.8	0.5	9.3	12.3	66.0	23.0
	J	0.6	6.6	0.0	0.0	3.3	17.0	42.0	12.5
	J	0.3	1.5	0.5	0.1	2.9	14.0	19.5	42.0
	A	0.3	2.0	0.5	0.0	4.5	17.1	20.0	55.0
	S	1.1	1.5	0.3	0.3	4.1	0.0	16.0	37.0
	O	0.0	0.9	0.2	0.1	0.6	0.3	9.0	34.0
	N	0.0	1.5	0.3	0.1	0.8	1.0	*	*
	D	0.1	0.6	0.3	0.0	0.4	0.1	15.1	33.0
	Ave	1.1	4.3	0.5	0.3	5.6	14.4	30.5	34.2

Table A-17. Leachate soluble Phosphate Concentration (mg PO_4/ℓ)
(Continued)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
1974	J	0.0	0.2	0.1	0.2	0.0	0.0	5.8	24.0
	F	0.0	0.0	0.1	0.0	0.8	0.6	19.0	25.0
	M	0.3	0.8	0.3	0.2	0.2	0.0	7.3	9.0
	A	0.1	0.1	0.0	0.1	0.1	0.0	0.6	29.0
	M	0.3	0.7	0.9	0.6	0.5	1.9	11.5	12.8
	J	0.5	0.5	0.3	0.0	0.0	3.4	2.8	9.8
	J	0.0	0.3	0.3	0.0	0.1	0.3	10.5	2.5
	A	0.1	0.0	0.3	0.1	1.3	2.3	5.0	11.8
	S	1.6	0.9	1.5	1.3	2.3	4.1	19.0	3.3
	O	0.0	1.5	0.3	0.1	0.0	0.0	18.0	15.0
	N	0.0	0.6	0.3	1.0	0.3	1.4	12.5	12.8
	D	0.3	0.6	0.1	1.1	0.0	1.1	5.5	11.3
	Ave	0.3	0.5	0.4	0.4	0.5	1.3	9.8	13.9
1975	J	0.3	0.3	0.3	0.0	0.0	0.0	36.0	15.0
	F	0.3	0.5	0.3	*	0.6	0.7	14.8	*
	M	0.5	1.1	0.4	0.5	0.1	1.3	7.9	15.3
	A	0.6	1.4	0.9	0.6	0.4	0.9	15.9	13.4
	M	0.3	0.7	0.5	0.3	0.4	1.0	6.8	9.2
	J	0.3	0.4	0.3	0.4	0.2	1.0	7.4	8.0
	J	0.3	0.4	** 0.5	** 1.0	0.1	0.3	12.0	8.3
	A	0.4	0.6	0.6	0.6	0.6	0.5	13.8	7.9
	S	0.2	0.5	0.0	0.8	0.2	0.4	14.2	11.0
	O	9.4	0.5	0.4	0.3	0.0	0.3	4.9	6.5
	N	0.2	0.8	0.4	0.3	0.1	0.3	3.5	4.8
	D	0.2	0.9	*	*	0.8	0.3	4.7	5.0
	Ave	1.1	0.7	0.4	0.5	0.3	0.6	11.8	9.5
1976	J	0.1	0.4	*	0.1	0.1	0.0	4.5	7.2
	F	0.2	0.4	0.2	0.8	0.1	0.2	5.2	4.2
	M	0.2	0.1	0.3	2.0	0.2	1.2	5.2	4.8
	A	0.4	0.6	0.3	1.4	0.2	2.0	4.4	6.0
	M	0.2	0.3	0.0	2.5	0.2	1.2	5.1	5.7
	J			0.1	2.9	0.2	3.0	7.0	6.2
	J			0.1	1.4			3.5	4.5
	A			0.2	1.4			3.1	4.6
	S			0.2	1.8			3.0	4.0
	O			0.2	1.1			0.6	3.4
	N			0.1	0.6			0.6	4.8
	D			*	0.1			0.3	3.6
	Ave	0.2	0.4	0.2	1.3	0.2	1.3	3.5	4.9
1977	J			*	0.4			0.6	4.1
	F			0.2	0.4			1.1	1.9
	M			0.2	2.7			2.5	11.8
	A			1.4	1.7			1.4	8.8
	M			0.3	1.2			0.8	4.4
	J			0.3	1.3			0.8	2.9
	Ave			0.5	1.3			1.2	5.6

*No data available

**New lift added

Table A-18. Average Leachate COD Production (g/day average since previous sampling)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
	S	1305	1759	473	310				
	O	75	171	94	53				
	N	35	173	0	11				
	D	14	0	178	72				
	Ave	357	526	186	112				
1971	J	204	651	363	229				
	F	677	2630	3948	2728				
	M	1108	3140	6198	2358				
	A	579	654	2342	2224				
	M	106	341	957	1077				
	J	189	362	2213	966				
	J	60	254	430	245				
	A	163	638	155	181				
	S	64	121	54	57				
	O	289	305	85	141				
	N	214	448	52	176				
	D	217	1031	246	151				
	Ave	322	881	1420	878				
1972	J	202	692	93	48				
	F	282	63	18	23				
	M	506	884	201	442				
	A	1184	2614	1675	1278				
	M	620	1516	517	460				
	J	114	533	65	58				
	J	74	200	42	37				
	A	702	1855	265	135	0	0	0	0
	S	1217	1412	183	131	0	238	0	0
	O	1057	1620	190	70	614	0	1475	14
	N	93	614	39	30	1378	1105	110	14
	D	188	452	342	87	67	77	87	0
	Ave	520	1038	302	233	412	284	334	6
1973	J	926	502	209	95	1753	386	1406	126
	F	197	354	112	69	2331	269	2838	233
	+ M	6629	6289	780	167	3060	611	9120	1722 +
	+ A	7291	6045	905	225	3104	301	22920	8729 +
	+ M	3818	10297	670	96	2614	182	18179	7699 +
	J	616	3547	82	38	1199	145	9264	2966
	J	312	1903	66	23	416	134	534	834
	A	136	305	37	18	93	28	760	460
	S	85	68	33	36	22	28	747	190
	O	23	65	18	20	163	39	2029	407
	N	141	677	55	26	48	15	0	0
	D	31	561	24	17	211	21	2697	552
	Ave. incl.+	1684	2551	249	69	1251	180	5874	1993
	Ave. excl.+	274	887	71	38	693	118	2253	641

Table A-18. Average Leachate COD Production (g/day average since previous sampling) (Continued)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
1974	J	48	209	65	24	59	11	2902	575
	F	153	313	94	34	289	24	5640	1659
	M	920	153	310	71	363	22	3131	2074
	A	227	1053	108	x 26	x 193	x 44	7371	7684
	M	636	809	115	x 35	x 645	x 84	6830	7327
	J	94	350	39	23	168	36	6277	3976
	J	5	49	14	4	29	13	1378	1068
	A	6	40	10	6	19	14	838	1281
	S	3	10	4	1	3	3	169	342
	O	5	16	4	2	10	9	953	1357
	N	32	78	14	3	7	4	775	1507
	D	6	23	33	4	20	4	1321	2078
	Ave	178	259	68	19	150	22	3132	2577
1975	J	2	9	5	0	5	4	1438	1539
	F	5	9	6	b *	2	5	266	0
	M	129	1265	46	b *	3	5	841	b *
	A	195	838	246	a 15	58	5	5237	a 3494
	M	15	427	21	3	16	17	2724	3654
	J	8	55	16	13	23	13	928	2563
	J	20	51	** 32	** 65	2	4	3706	4571
	A	4	28	19	11	6	1	449	b *
	S	3	6	8	7	4	6	1420	a 878
	O	2	4	5	1	1	2	777	819
	N	15	23	14	9	1	3	613	549
	D	5	25	0	0	2	4	1066	154
	Ave	34	228	35	12	10	6	1622	1822
1976	J	1	5	0	2	1	2	706	1005
	F	15	x 75	20	36	0	0	587	336
	M	111	359	74	1108	8	6	2949	6477
	A	106	226	36	510	12	7	4455	6828
	M	6	278	24	1111	13	5	3825	5338
	J			4	94	3	6	1755	1599
	J			16	71			1786	1420
	A			10	48			1308	1181
	S			2	22			1241	646
	O			2	20			1187	585
	N			1	5			644	435
	D			0	1			47	417
	Ave	48	189	16	252	6	4	1708	2189
1977	J			0	0			43	236
	F			6	5			755	2181
	M			7	68			1772	4019
	A			12	177			1650	3939
	M			7	161			1110	1741
	J			10	194			1082	1177
	Ave			7	101			1069	2216

* No data available

** New lift added

x gutter broken, runoff probably in leachate system

a total since previous successful sampling

b pump breakdown

Table A-19. Oxygen Concentration (%O_2)

Cells 1-6:2'&4' averages; Cells 7&8:3',5'&7' averages;
Cells 3&4 after 7/75:1',3',5'&8' averages.

Year	Month	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
	S	0.0	0.0	5.8	0.0				
	O	0.0	0.0	0.0	0.0				
	N	1.2	1.2	1.0	1.2				
	D								
	Ave								
1971	J	0.2	0.4	0.4	0.6				
	F	1.3	1.7	1.4	1.0				
	M	0.8	0.6	0.3	0.6				
	A	*	*	*	*				
	M	1.2	1.2	1.6	1.6				
	J	1.6	1.2	2.3	2.2				
	J	0.6	0.8	0.3	0.6				
	A	1.0	1.0	0.5	0.8				
	S	1.5	1.2	0.9	1.0				
	O	1.8	1.0	1.3	1.2				
	N	0.8	0.3	0.2	0.8				
	D	0.7	** 9.0	** 0.4	** 7.8				
	Ave	1.0	1.7	0.9	1.7				
1972	J	1.8	0.6	0.0	8.1				
	F	0.7	0.7	10.2	11.6				
	M	** 8.4	** 6.1	1.0	2.7				
	A	0.3	8.4	0.7	9.1				
	M	2.0	1.2	1.0	6.2				
	J	11.6	3.9	2.6	7.8				
	J	1.8	1.5	2.8	11.4				
	A	0.0	3.0	8.4	16.5				
	S	*	*	*	*	7.0	10.5	17.8	20.7
	O	3.0	2.2	5.1	11.5	11.5	13.8	11.6	19.8
	N	3.4	10.4	0.8	1.4	11.2	20.6	19.7	19.0
	D	*	*	*	*	8.8	18.1	18.6	18.2
	Ave	3.3	3.8	3.3	8.6				
1973	J	5.9	9.5	2.6	13.6	10.3	20.4	17.9	18.6
	F	*	*	*	*	9.2	20.1	14.8	19.1
	M	10.9	20.3	20.0	19.2	13.9	16.8	12.3	20.4
	A	19.0	19.5	19.2	19.8	18.4	17.4	14.6	18.7
	M	2.2	1.9	0.0	4.4	9.8	17.2	12.9	15.1
	J	6.5	12.3	1.8	5.2	5.4	17.9	20.2	19.5
	J	4.7	2.0	0.0	2.4	8.0	15.7	8.8	13.4
	A	0.6	0.0	0.0	5.2	9.2	16.8	11.4	18.2
	S	0.0	0.0	0.0	6.1	12.8	18.5	9.3	17.9
	O	0.3	0.9	0.0	11.1	20.9	20.9	11.7	16.5
	N	7.4	0.0	0.0	14.1	18.8	20.5	13.6	16.1
	D	2.5	5.8	2.5	14.8	19.8	20.0	11.4	15.1
	Ave	5.5	6.6	4.2	10.5	13.0	18.5	13.2	17.4

Table A-19. Oxygen Concentration (%O_2) (Continued)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
1974	J	0.0	5.2	0.0	17.2	19.2	22.4	10.8	19.9
	F	1.1	2.4	0.0	14.0	19.6	20.1	10.5	15.6
	M	6.0	0.0	0.0	13.0	20.4	20.4	10.8	16.6
	A	4.1	0.0	2.4	4.6	18.0	20.6	11.5	16.1
	M	0.0	9.0	18.5	9.8	17.4	20.2	11.4	16.1
	J	0.0	0.0	6.5	6.2	18.4	20.2	14.1	17.3
	J	0.0	0.0	0.0	5.0	6.0	18.4	13.8	16.9
	A	0.0	0.0	0.0	6.8	8.0	17.2	9.9	16.4
	S	0.0	0.0	0.0	7.6	13.3	20.8	9.9	15.4
	O	0.0	0.0	0.0	24.1	11.4	22.4	14.4	18.2
	N	0.0	0.0	0.0	17.0	17.6	22.4	13.2	18.1
	D	0.0	0.0	1.1	20.2	18.7	20.2	13.5	15.7
	Ave	0.9	1.4	2.4	12.1	15.7	20.4	12.0	16.9
1975	J	0.0	0.0	0.0	20.0	18.1	19.8	14.8	18.2
	F	*	*	12.2	15.0	19.9	20.8	** 0.0	** 20.9
	M	0.0	*	*	18.7	21.0	22.0	** 3.2	** 19.7
	A	4.6	2.0	0.0	15.7	22.2	22.0	** 0.0	** 7.6
	M	0.0	2.3	0.0	10.2	19.8	19.4	** 0.0	** 7.3
	J	*	*	*	*	12.6	19.8	6.5	9.9
	J	*	*	x *	x *	*	*	*	*
	A	*	*	*	*	*	*	*	*
	S	1.9	0.6	4.2	4.8	20.5	22.6	15.5	22.7
	O	0.0	0.0	3.8	2.8	19.4	19.6	6.5	3.8
	N	0.8	0.0	5.8	7.0	18.6	17.3	6.1	5.7
	D	5.4	0.0	15.9	14.0	18.0	19.8	1.5	4.0
	Ave	1.6	0.7	5.2	12.0	19.0	20.3	5.4	12.0
1976	J	2.0	0.3	14.3	9.2	20.2	16.8	0.4	2.4
	F	0.5	17.6	3.5	8.6	20.8	16.8	7.2	6.2
	M	1.8	7.8	9.6	6.9	21.4	20.8	4.6	4.5
	A	0.0	0.0	6.0	10.1	13.1	17.6	5.0	1.5
	M	0.3	0.7	8.8	10.3	20.4	19.0	0.4	2.2
	J			*	*	17.1	17.0	3.1	2.3
	J			6.4	9.3			0.0	1.7
	A			*	*			*	*
	S			18.9	14.6			6.6	11.2
	O			17.6	14.0			8.7	6.4
	N			12.6	7.7			3.0	7.0
	D			8.6	2.8			1.4	8.0
	Ave	0.9	5.3	10.6	9.4	18.8	18.0	3.7	4.9
1977	J			3.8	0.0			1.2	7.2
	F			3.8	0.9			2.4	5.7
	M			0.4	4.6			1.2	4.4
	A			1.9	4.2			7.1	2.7
	M			2.8	3.6			1.4	4.6
	Ave			2.5	2.7			2.7	4.9

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*Data unavailable or unreliable

**New probes or may be unreliable due to only one data value available

[x] New lift added.

Table A-20. Carbon Dioxide Concentration (%CO_2)

Cells 1-6:2'&4' averages; Cells 7&8:3',5', &7' averages;
Cells 3&4 after 7/75:1',3',6', & 8' averages.

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
	S								
	O	16.8	25.3	12.8	10.8				
	N	21.7	31.6	18.4	18.5				
	D	16.4	20.2	19.1	21.3				
	Ave								
1971	J	15.3	16.7	20.4	19.3				
	F	19.8	21.2	19.0	21.0				
	M	17.4	17.8	26.2	17.6				
	A	*	*	*	*				
	M	20.3	23.2	30.2	25.1				
	J	21.2	25.3	28.6	22.2				
	J	22.2	24.4	30.5	26.3				
	A	20.7	23.2	27.6	27.8				
	S	17.0	21.2	24.4	23.8				
	O	15.4	19.5	18.0	18.2				
	N	14.2	17.1	19.2	20.1				
	D	15.9	** 11.4	** 23.8	** 13.1				
	Ave	18.1	20.1	24.4	21.3				
1972	J	14.8	21.6	23.2	9.0				
	F	15.0	18.1	11.2	8.0				
	M	** 8.6	** 14.8	17.0	** 9.9				
	A	16.1	13.0	18.9	8.8				
	M	19.8	26.0	24.9	18.0				
	J	18.8	23.4	29.6	24.2				
	J	18.9	22.2	24.6	16.4				
	A	28.0	30.0	21.4	9.2				
	S	*	*	*	*	15.3	10.8	5.6	0.7
	O	19.0	25.0	23.2	11.4^	10.0	5.0	22.3	0.4
	N	14.6	15.7	30.2	22.0	9.2	0.8	2.0	3.4
	D	*	*	*	*	9.9	0.7	1.9	1.3
	Ave	17.4	21.0	22.4	13.7				
1973	J	10.1	12.7	19.0	5.2	11.9	0.0	3.1	1.6
	F	*	*	*	*	10.8	0.0	5.8	0.6
	M	11.1	1.7	3.0	0.7	6.7	3.3	8.1	0.0
	A	1.0	2.2	1.2	1.6	0.0	1.1	9.4	0.2
	M	22.2	37.6	32.0	18.1	10.0	2.8	14.9	7.5
	J	15.6	15.6	32.6	19.2	18.3	4.8	1.5	2.0
	J	17.6	26.0	38.2	21.6	13.1	8.4	22.5	5.5
	A	17.2	29.2	35.4	13.8	11.5	3.0	18.4	2.0
	S	18.8	29.3	35.8	13.7	5.7	0.0	17.3	3.7
	O	17.1	32.4	34.0	9.8	0.0	0.0	12.9	2.7
	N	7.9	31.2	28.0	3.8	0.0	0.0	10.3	3.7
	D	14.6	18.4	24.0	5.4	0.0	0.0	8.2	3.2
	Ave	13.9	21.5	25.7	10.3	7.3	2.0	11.0	2.7

Table A-20. Carbon Dioxide Concentration (%CO_2) (Continued)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
1974	J	16.5	21.8	28.2	1.7	2.1	0.0	10.4	0.0
	F	14.8	24.2	24.6	2.8	0.0	0.0	10.3	3.7
	M	11.3	29.4	22.0	5.4	0.0	0.0	9.2	3.5
	A	14.6	28.4	23.1	14.8	1.2	0.0	9.7	3.2
	M	21.0	12.6	0.0	7.1	1.5	0.0	12.2	4.5
	J	21.8	33.2	19.8	12.8	2.2	0.0	9.4	2.9
	J	22.8	37.0	32.2	12.1	8.8	0.0	10.5	2.6
	A	19.2	33.4	27.8	10.1	9.2	0.0	14.1	2.7
	S	19.2	27.7	22.0	10.3	3.2	0.0	12.0	3.9
	O	18.5	33.4	23.1	0.0	8.2	0.0	9.6	3.8
	N	17.6	32.4	20.0	0.0	0.0	0.0	7.6	0.0
	D	15.1	28.4	17.0	0.0	0.0	0.0	8.2	3.8
	Ave	17.7	28.5	21.6	6.4	3.0	0.0	10.3	2.9
1975	J	15.6	33.0	21.7	0.0	0.0	0.0	4.1	0.0
	F	*	*	8.0	2.4	0.0	0.0	** 26.1	** 0.0
	M	16.6	*	*	0.0	0.0	0.0	** 21.3	** 0.0
	A	12.8	26.7	20.6	2.6	0.0	0.0	** 25.6	** 13.2
	M	22.2	28.8	26.3	8.2	0.0	0.0	** 29.0	** 16.0
	J	*	*	*	*	6.9	1.0	** 24.0	** 14.0
	J	*	*	x *	x*	*	*	*	*
	A	*	*	*	*	*	*	*	*
	S	21.4	30.4	22.4	15.4	0.0	0.0	18.6	0.4
	O	20.6	27.0	24.0	18.5	0.0	0.0	28.9	25.0
	N	16.1	29.6	17.6	14.6	0.0	2.0	28.4	18.0
	D	12.5	29.4	2.6	5.8	0.0	0.0	32.6	19.0
	Ave	17.2	29.3	17.9	7.5	0.7	0.3	23.9	10.6
1976	J	13.4	24.4	13.2	7.9	0.0	1.3	26.9	16.8
	F	9.0	3.0	8.6	8.2	0.0	0.0	9.6	7.5
	M	17.8	12.9	10.0	12.4	0.0	0.0	15.3	11.5
	A	11.4	21.8	11.6	5.2	3.3	0.0	16.5	16.9
	M	20.1	30.4	13.8	7.8	0.0	0.9	23.6	15.2
	J			*	*	0.7	1.0	24.1	17.5
	J			14.0	5.6			37.2	28.1
	A			*	*			*	*
	S			2.0	2.4			31.4	18.3
	O			0.0	5.4			22.4	20.8
	N			7.2	16.0			29.3	15.2
	D			12.0	25.1			27.2	12.5
	Ave	14.3	18.5	9.2	9.6	0.7	0.5	24.0	16.4
1977	J			22.0	24.6			21.9	11.3
	F			22.2	24.2			16.0	9.9
	M			25.8	16.6			18.3	10.8
	A			24.7	21.2			14.0	14.6
	M			26.2	20.8			28.3	16.1
	Ave			24.2	21.5			19.7	12.5

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*Data unavailable or unreliable

**New probes or may be unreliable due to only one data value available

xNew lift added

Table A-21. Methane Concentration (%CH_4)

Cells 1-6:2'&4' averages; Cells 7&8:3',5'&7' averages;

Cells 3&4 after 7/75: 1',3',6' &8' averages.

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
	S	0.0	0.0	0.0	0.0				
	O	0.0	0.0	0.0	0.0				
	N	0.0	0.8	0.0	0.0				
	D								
	Ave								
1971	J	0.0	0.5	6.0	0.0				
	F	0.0	0.6	6.4	0.0				
	M	0.0	0.0	6.4	0.0				
	A	*	*	*	*				
	M	0.0	0.0	2.0	0.8				
	J	0.0	0.8	7.4	1.1				
	J	0.0	0.3	23.2	17.5				
	A	0.0	0.7	26.7	24.8				
	S	0.0	2.6	20.8	12.5				
	O	0.0	1.2	1.6	2.0				
	N	0.0	0.8	7.2	7.6				
	D	0.0	** 0.8	** 34.0	** 11.6				
	Ave	0.0	0.8	12.9	7.1				
1972	J	0.0	7.0	39.6	1.8				
	F	0.0	4.5	7.7	0.0				
	M	** 0.0	**0.0	6.8	0.0				
	A	0.0	0.0	14.2	0.0				
	M	0.0	2.5	37.6	6.8				
	J	0.0	5.0	28.0	13.5				
	J	0.0	4.6	20.4	6.2				
	A	6.0	12.4	19.4	0.0				
	S	*	*	*	*	0.0	0.0	0.0	0.0
	O	10.4	30.4	23.9	4.5	1.3	0.0	0.0	0.0
	N	1.2	25.2	29.7	11.7	2.8	0.0	0.0	0.0
	D	*	*	*	*	0.0	0.0	0.0	0.0
	Ave	1.8	9.2	22.7	4.4				
1973	J	0.0	10.5	20.1	0.0	1.5	0.0	0.0	0.0
	F	*	*	*	*	6.6	0.0	0.0	0.0
	M	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0
	A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	M	1.4	38.2	44.2	17.6	4.3	0.0	0.0	0.0
	J	0.0	9.3	35.3	9.4	6.8	0.0	0.0	0.0
	J	1.6	14.4	50.2	15.4	5.8	0.6	4.9	2.0
	A	0.0	24.1	41.0	0.0	4.4	0.0	1.2	0.0
	S	0.0	16.2	37.2	0.0	0.0	0.0	0.0	0.0
	O	0.0	38.2	35.9	0.4	0.0	0.0	0.0	0.0
	N	0.0	25.6	7.8	0.0	0.0	0.0	0.0	0.0
	D	0.0	25.2	30.2	0.0	0.0	0.0	0.0	0.0
	Ave	0.3	18.3	27.4	3.9	2.6	0.0	0.5	0.2

Table A-21. Methane Concentration (%CH_4) (Continued)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
1974	J	0.0	24.8	28.5	0.0	0.0	0.0	0.0	0.0
	F	0.0	31.6	12.6	0.0	0.0	0.0	0.0	0.0
	M	0.0	51.4	15.6	0.0	0.0	0.0	0.0	0.0
	A	0.0	52.5	26.3	0.0	0.0	0.0	0.0	0.0
	M	9.0	5.2	0.0	0.0	0.0	0.0	0.0	0.0
	J	0.0	34.2	16.9	0.0	0.0	0.0	0.0	0.0
	J	2.2	23.2	22.8	0.0	0.0	0.0	0.0	0.0
	A	1.0	21.6	14.2	0.0	0.0	0.0	0.0	0.0
	S	0.0	15.4	6.9	0.0	0.0	0.0	0.0	0.0
	O	0.0	41.8	8.6	0.0	0.0	0.0	0.0	0.0
	N	0.8	55.0	8.8	0.0	0.0	0.0	0.0	0.0
	D	0.0	43.4	4.0	0.0	0.0	0.0	0.0	0.0
	Ave	1.1	33.3	13.8	0.0	0.0	0.0	0.0	0.0
1975	J	0.0	51.7	10.4	0.0	0.0	0.0	0.0	0.0
	F	*	*	0.0	0.0	0.0	0.0	** 0.0	** 0.0
	M	0.0	*	*	0.0	0.0	0.0	** 0.0	** 0.0
	A	0.0	40.8	11.6	0.0	0.0	0.0	** 0.0	** 0.0
	M	0.0	47.8	28.7	0.0	0.0	0.0	** 0.0	** 0.0
	J	*	*	*	*	0.0	0.0	4.8	0.0
	J	*	*	x *	x *	*	*	*	*
	A	*	*	*	*	*	*	*	*
	S	2.7	23.2	20.1	3.8	0.0	0.0	8.9	0.0
	O	2.0	20.4	14.0	2.0	0.0	0.0	18.3	3.9
	N	1.7	35.8	10.9	1.0	0.0	1.8	19.3	3.1
	D	0.0	38.2	0.0	0.0	0.0	0.0	17.7	0.5
	Ave	0.8	36.8	12.0	0.8	0.0	0.2	6.9	0.8
1976	J	0.0	16.9	9.4	0.0	0.0	1.4	7.4	0.6
	F	0.0	0.0	4.2	0.0	0.0	0.0	3.3	0.3
	M	0.0	23.8	1.3	15.6	0.0	0.0	2.3	0.2
	A	1.1	34.3	1.5	26.6	0.0	0.0	6.1	0.0
	M	0.9	38.8	1.6	24.8	0.0	0.0	9.2	0.4
	J			*	*	0.0	0.0	13.7	2.3
	J			4.7	20.3			30.0	5.6
	A			*	*			*	*
	S			0.2	3.1			25.4	7.5
	O			0.0	0.3			19.7	5.8
	N			0.0	6.4			21.5	2.0
	D			0.0	29.6			14.8	1.8
	Ave	0.4	22.8	2.3	12.7	0.0	0.2	13.9	2.4
1977	J			17.5	28.0			8.7	0.4
	F			16.0	25.6			1.1	1.0
	M			19.6	15.6			4.5	0.0
	A			22.8	27.4			7.4	0.4
	M	—	—	21.6	50.5	—	—	22.9	0.5
	Ave			19.5	29.4			8.9	0.5

*Data unavailable or unreliable

**New probes or may be unreliable due to only one data value available

xNew lift added

Table A-22. Average Refuse Temperature (°F)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
	S	74.8	75.8	90.3	88.5				
	O	67.2	58.0	115.0	116.4				
	N	59.5	57.0	97.7	99.8				
	D	53.8	52.0	75.0	71.7				
1971	J	*	*	*	*				
	F	49.2	48.2	65.3	61.2				
	M	*	*	*	*				
	A	52.5	52.7	54.5	61.7				
	M	61.0	58.5	62.5	72.3				
	J	62.4	63.3	66.4	78.1				
	J	66.8	67.2	69.4	80.4				
	A	70.5	67.9	68.2	83.0				
	S	69.8	64.2	64.2	83.0				
	O	*	*	*	*				
	N	64.0	52.9	52.0	71.0				
	D	45.0	49.2	48.0	56.2				
1972	J	51.0	43.7	41.3	51.3				
	F	48.3	38.7	37.7	42.3				
	M	45.0	38.7	38.3	39.7				
	A	52.7	45.3	44.7	52.3				
	M	60.7	49.7	53.0	60.0				
	J	69.4	55.5	59.5	74.8				
	J	74.4	61.9	67.6	88.8				
	A	75.2	66.3	70.2	84.7	104.3	100.2	109.9	103.8
	S	80.7	63.0	66.8	80.7	99.6	102.0	106.7	98.8
	O	73.6	55.0	62.8	63.0	89.0	100.7	96.0	87.0
	N	52.2	43.0	44.4	52.4	72.8	95.2	81.0	73.7
	D	53.7	42.0	45.0	49.5	72.0	89.2	71.8	64.6
1973	J	54.6	39.8	35.8	41.1	57.5	97.3	62.6	58.9
	F	53.8	39.5	37.8	37.3	56.1	91.7	56.5	57.0
	M	53.0	39.4	40.0	43.5	62.2	85.6	50.3	56.7
	A	53.6	44.8	41.6	43.2	66.1	77.2	50.4	61.8
	M	63.0	52.7	51.7	55.2	71.6	81.2	59.5	64.8
	J	81.4	55.0	63.7	66.9	80.8	83.6	58.8	67.5
	J	80.5	65.8	71.2	72.7	94.4	90.2	63.9	73.4
	A	80.7	66.3	70.8	77.5	97.3	90.8	68.2	76.5
	S	78.3	54.2	67.5	75.7	92.2	86.6	75.4	78.0
	O	74.0	49.0	62.1	61.1	82.0	77.5	75.1	75.0
	N	71.7	42.8	57.5	57.2	77.2	72.2	71.2	75.0
	D	57.2	32.7	42.7	40.5	61.5	57.8	59.8	65.8

Table A-22. Average Refuse Temperature (°F) (Continued)

		Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
1974	J	60.9	31.4	45.3	37.5	54.1	45.1	56.4	56.7
	F	51.8	33.7	44.3	37.9	52.4	43.6	51.0	53.2
	M	50.4	34.2	43.1	37.3	51.5	44.4	45.9	51.6
	A	51.5	30.3	44.7	37.2	54.3	46.7	43.3	50.7
	M	54.7	35.6	52.6	45.8	66.6	57.5	48.4	59.5
	J	58.0	40.5	56.1	51.3	73.8	63.7	54.6	66.7
	J	67.8	47.0	67.3	59.0	93.8	78.2	63.0	69.0
	A	68.2	51.4	65.2	60.6	87.6	77.2	73.4	71.0
	S	70.0	52.8	60.6	60.6	88.8	64.5	74.8	71.0
	O	67.2	45.2	57.9	52.0	79.8	58.0	74.6	68.5
	N	61.2	42.4	40.6	42.8	68.4	48.2	72.6	64.8
	D	54.2	36.7	42.1	44.0	54.9	43.6	68.7	59.3
1975	J	49.0	32.8	31.2	36.6	52.8	39.2	59.4	56.4
	F	43.2	29.2	41.0	29.4	49.2	35.2	53.2	55.8
	M	48.4	33.5	28.8	28.8	47.5	36.8	50.6	51.4
	A	45.4	36.5	31.4	30.6	51.7	44.2	46.0	47.5
	M	54.0	45.0	45.0	40.2	70.2	65.4	47.0	56.2
	J	66.4	51.8	49.5	63.2	80.3	74.8	60.4	65.7
	J	65.5	54.5	**53.8	**58.6	91.4	72.6	61.9	63.2
	A	64.0	52.7	57.0	64.9	87.1	65.2	66.8	67.2
	S	55.4	41.6	51.8	55.8	78.9	52.0	69.0	64.2
	O	52.6	40.0	48.4	51.4	76.3	46.5	69.0	64.0
	N	46.8	36.1	47.7	52.6	69.6	43.4	68.8	61.9
	D	42.4	31.0	44.8	48.6	54.4	37.4	62.0	57.3
1976	J	40.6	26.0	38.6	46.0	47.7	29.8	51.4	52.3
	F	31.4	27.8	36.2	42.5	43.6	32.3	42.9	48.7
	M	35.2	24.5	35.3	49.4	43.8	31.0	40.2	44.0
	A	40.8	33.2	35.4	58.6	54.6	36.1	40.5	49.1
	M	43.1	38.8	37.1	75.0	64.8	45.5	44.5	54.7
	J	49.0	51.3	38.3	59.8	77.3	53.6	50.3	59.8
	J			45.9	61.2			58.4	64.5
	A			44.4	64.4			68.9	68.0
	S			44.7	64.7			69.2	68.0
	O			45.2	68.2			65.6	66.3
	N			44.6	65.0			60.7	61.4
	D			44.2	64.2			55.0	53.3
1977	J			41.2	55.4			47.2	50.6
	F			40.0	51.4			41.7	40.0
	M			38.2	51.0			37.4	44.1
	A			37.4	54.5			37.2	44.4
	M			40.0	57.8			44.0	53.5
	J			39.7	61.5			53.2	57.2

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*No data available

**New lift added

TECHNICAL REPORT DATA

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1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE DECOMPOSITION OF RESIDENTIAL-LIGHT COMMERCIAL SOLID WASTE IN TEST LYSIMETERS		5. REPORT DATE Submitted November, 1979 6. PERFORMING ORGANIZATION CODE
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16. ABSTRACT

The monitoring of eight large test lysimeter cells has given information about the decomposition of, and leachate and gas production from, shredded and unprocessed refuse. Six of the cells were originally 4 to 5 feet deep and held 100 tons each of residential-light commercial municipal solid waste. Two cells were originally 8 to 10 feet deep and held 200 tons each. All cells were exposed to the climate at Madison, Wisconsin, for 5 to 7 years.

Cell monitoring was designed to indicate changes in leachate quantity and composition and gas composition, as a result of: (1) shredding or not shredding the waste, (2) covering or not covering the waste with soil, (3) increasing the depth of a lift from 4 feet to 8 feet, and (4) building an 8-foot layer in a landfill in one or two lifts.

Increased peak concentrations of contaminants in leachate were common with shredded refuse, in comparison with unprocessed refuse. The effect of soil cover on the cells was to prolong the period of production of leachate high in contaminant concentrations. The cells left uncovered produced initially a highly contaminated leachate, followed by rapid stabilization to consistently low concentrations of contaminants.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Refuse disposal Leaching Lysimeters Gases Decomposition reactions	Solid waste management Sanitary landfills Leachate	13B

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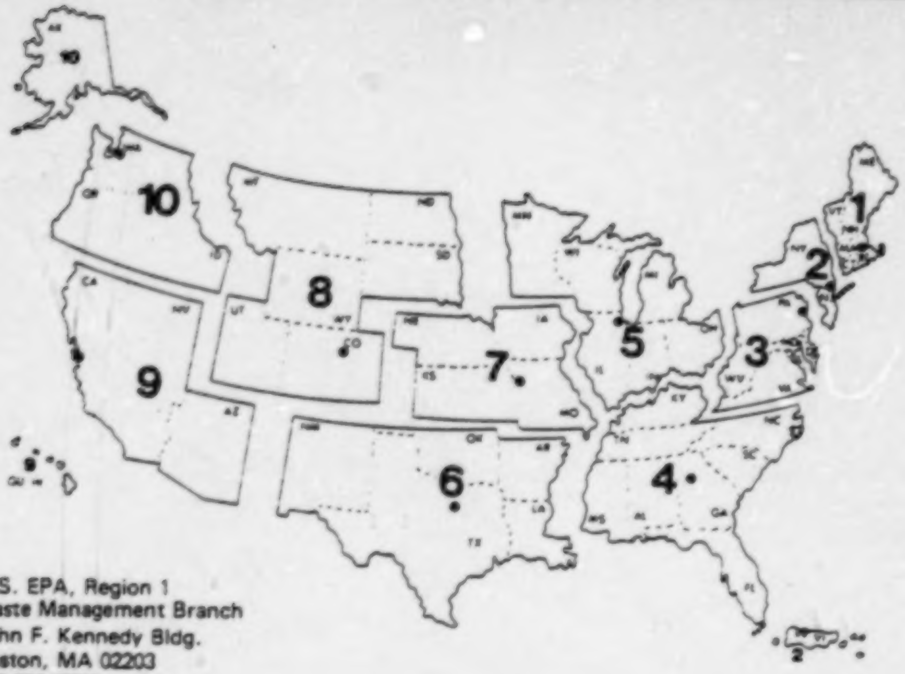

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816-374-3307

U.S. EPA, Region 8
Waste Management Branch
1860 Lincoln St.
Denver, CO 80295
303-837-2221

U.S. EPA, Region 9
Hazardous Materials Branch
215 Fremont St.
San Francisco, CA 94105
415-556-4606

U.S. EPA, Region 10
Waste Management Branch
1200 6th Ave.
Seattle, WA 98101
206-442-1260